

Exploring science identity among Jordanian high school students: a case study

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ABSTRACT

This study aimed to investigate the validity and reliability of the Arabic version of the science identity scale (SIS) and to explore any differences in levels of science identity due to gender. The study sample comprised 304 male and female high school students who had completed the SIS. To achieve study objectives, exploratory factor analysis and confirmatory factor analysis were used. The results of the exploratory factor analysis showed that four factors explained (40.542%) of total variance. The results of the confirmatory factor analysis indicated a good model fit, and the Cronbach alpha was calculated to be 0.85 for the SIS. Finally, the results revealed statistically significant differences in the level of science identity and its subscales (science performance, science competence, science recognition, and science interest) based on the gender variable, with females scoring higher. The study recommends that teachers utilize the SIS to assess the level of science identity among students and implement teaching practices aimed at enhancing the science identity of secondary school students.

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1. INTRODUCTION

According to previous studies [1], [2], research on identity theory has concluded that an individual incentive and dynamic drive to undertake and fulfil social roles and responsibilities they identify with is their identity. Identity can manifest as a group of values expressing an individual's chosen societal role, a group membership, or specific individuality claimed by the person. In educational studies, the concept of identity has a wide range of contexts and structures. A definition by Kuchynka *et al.* [3] classified identity as certain type of person, based on an individual's self-perception and how others perceive them, but also suggests that an individual can have multiple identities.

Rüschepöhler and Markic [4] argued that identities can be seen as narratives unfolding in various constructs of time, space, affiliations, and connections. In addition, Wang and Hazari [5] argued that narratives are not solely meaning-based presentations or dialogue without action but combine both and are therefore subjectivities or positions with biases or prejudice. Given the various settings of these depictions, the narratives should be considered multimodal, given the relationship between learning and identities. The learning process is not merely an information construct assembling facts to present a concept, similar to completing a jigsaw puzzle, but also requires individuals to consider themselves in relation to the learning concept procedure [4].

Anderhag *et al.* [6] highlighted the fact that students transitioning from primary to secondary education often show a marked lack of interest in pursuing science studies and careers. Kim *et al.* [7] link this trait to the lack of alignment between what students do in the science classroom and their aspirations for the future, especially if those aspirations are not specifically science-related. This misalignment can have a negative impact on the development of science identities. One approach to encourage student enthusiasm is to give them access to scientists in various professional domains. However, Bamberger [8] found that such interaction could negatively impact students' science identity by causing doubt about their ability to meet the demands of such professions. Clearly, there is an urgent need for effective instructional strategies that enable students to connect their science classroom learning with their future aspirations.

Howard and Borgella [9] proposed a straightforward interpretation of science identity as the self-view and how individuals are viewed or recognized by others from the perspective of being a "science person." This perspective is firmly embedded in both the aspiration to become a "science person" and the societal acceptance of this identity. Avraamidou [10] echoed these opinions, emphasizing that science identity is crucial not only for understating science non-participation but also for examining and understanding the full complex scope of being a "science person", encompassing connections to social, organizational, and political issues.

Several researchers [11], [12] asserted that although the concept of science identity is now at the forefront of science education research, its complexity hinders its use as an investigative tool. Howard and Borgella [9] in their quest for a deeper understanding of students' self-identity in science-related arenas, created a science identity model upon which to base their practicing scientist case study. Drawing from Kuchynka *et al.* identity theory [3], their theoretical framework combined three overlapping modules. The first is competence; this module the capability to comprehend scientific knowledge content [13]. Competencies are the experiences, training, or areas of expertise gained over time in a specific field. This definition serves as the benchmark against which an individual's sense of competence is measured [14], [15]. However, Shein *et al.* [16] pointed out that the meaning of competence can differ based on the environment, opportunity, and other factors, as it is not an inherent individual trait but rather developed based on the environment, encouragement, and opportunities for participation and demonstration of competencies. Carlone [14] suggests that the definition of scientific competence is rooted in communal practice, with students evolving into specific types of students in a contextual science location or situation.

Second is performance; this aspect relates to the social performance of scientific practices within the public sphere and culture of science [14]. Performance can be defined as a configuration of actions carried out by members of a group who share common commitments and expectations, employing specific language in communication and the use of tools. It encompasses practices that contribute to the development and modification of explanations, justifications, or problem-solving. Scientific performance includes activities such as investigation, communication, inference, evaluation, and more, all aimed at understanding or strengthening knowledge statements. It involves examining, analyzing, data collection, problem-solving, and experimentation. Communicative practices encompass questioning, interpretive answer generation, and discussion. Epistemic practices involve inference, justification, evaluation, and legitimization of scientific knowledge [17]. Performances are context-dependent and produced through interactive participation of onsite contributors and their respective backgrounds [14].

Lastly, recognition; this dimension encompasses both self-recognition and being recognized as a "science person" by others. The identity concept must first be assumed through self-recognition and then become evident in social interaction. A full understanding of identity development should consider both external and internal descriptions to avoid discrepancies [18]. To avoid mismatches in perceptions, it is important to observe learners' external performance and consider related instructions, placing observed performance and learners' narrations into context [19]. This justifies the inclusion of surveys and follow-up interviews with those making observations to clarify the significance of behavior [9], [18]. Views, opinions, and assessment of competency are crucial. In addition to the personal benefits of adhering to these principles, for the students to be considered to possess a strong science identity, they need not only to perceive themselves as highly rated in the three dimensions but also to be so rated by others [9].

In previous study, Gresalfi [20] noted that students' participation in science class was strongly influenced by their science identities. The importance of science identity should be emphasized in understanding students' science learning, allowing science educators to gain a deeper appreciation of students' qualities and ambitions and encouraging the development of appropriate and meaningful teaching methods [21]. This study holds several significant implications. First, it represents the first attempt, to the best of the researcher's knowledge, in Arab studies in general and Jordanian research in particular, to explore the concept of science identity. Second, it provides an Arabic version of the science identity scale (SIS) for assessing the science identity of secondary school students. Third, the SIS can aid teachers in choosing educational practice that enhances students' science identity. Fourth, researchers can use the scale to gain a deeper and more comprehensive understanding of the formation of students' science identity. Last, the scale

can be employed to evaluate science programs in schools, ultimately increasing students' knowledge, interest, and participation in science subjects. This study aims to achieve the following objectives: i) to examine the validity and reliability of the SIS in the Arabic version; and ii) to investigate whether there are significant differences in the level of science identity due to gender.

2. RESEARCH METHOD

2.1. Research approach

In this study, the descriptive approach was employed because it is the most suitable approach for achieving the study objectives. The exploratory factor analysis, confirmatory factor analysis, and internal consistency were assessed using Cronbach's alpha. The independent sample t-test was used to investigate the differences in the level of science identity due to gender.

2.2. Study sample

The study population consisted of 6,122 high school students. The study sample included 304 high school students, with 134 (44.1%) males and 170 (55.9%) females. According to their grade level, 122 (40.1%) were in the eighth grade, 91 (29.9%) were in the ninth grade, and 91 (29.9%) were in the tenth grade. A total of 350 scales were distributed to the students, and 46 scales were excluded due to incomplete responses by the student. All students in the study sample attended government high schools and participated voluntarily. The choice of government schools was based on their prevalence in the educational area where the study was conducted, as private high schools are limited in this region, primarily offering elementary education. According to Simarjeet [22], the sample size in this study is considered acceptable.

2.3. Study instrument

The science identity scale used in this study was developed by Chen and Wei [23]. The science identity scale consists of four subscales: science performance (6 items), science competence (6 items), science recognition (4 items), and science interest (8 items). The internal consistency of the scale was measured using Cronbach's alpha, which yielded a value of 0.95.

2.4. Data collection and analysis

The SIS was translated from English into Arabic and then re-translated, with validation by two faculty members from the English Department to ensure accuracy and integrity. The scale was initially administered to an exploratory sample of 50 high school students to verify the linguistic formulation of the scale items. Based on feedback from the students, some scale items were modified for clarity. Following this validation process, the scale was administered to the study sample. To achieve the first objective of the study, which is to examine the validity and reliability of the SIS in its Arabic version, exploratory factor analysis, confirmatory factor analysis, and internal consistency (Cronbach's alpha) were used. To achieve study objective two, independent sample t-tests were used. SPSS version 24 and Amos version 24 were used to analyze the data.

3. RESULTS AND DISCUSSION

The first objective of the study is to examine the validity and reliability of SIS in the Arabic version. To accomplish the first objective and to examine the validity of SIS in the Arabic version, the exploratory factor analysis and confirmatory factor analysis were used. Internal consistency was assessed using Cronbach's alpha were used to examine the reliability of SIS in the Arabic version.

3.1. Exploratory factor analysis

The results of the exploratory factor analysis indicated four subscales of the science identity scale (science performance, science competence, science recognition and science interest), and the four factors explained of (40.542%) of total variance. The Kaiser-Meyer-Olkin (KMO) value of 0.868, and Bartlett's test of sphericity yielded a Chi-square value of 1515.290 (df=276, Sig=0.00). The factor loadings of the items are presented in Table 1.

Table 1. Results of exploratory factor analysis

Science performance		Science competence		Science recognition		Science interest			
Items number	Factor loadings	Items number	Factor loadings	Items number	Factor loadings	Items number	Factor loadings	Items number	Factor loadings
P1	0.523	C1	0.404	R1	0.512	I1	0.469	I5	0.741
P2	0.475	C2	0.456	R2	0.646	I2	0.607	I6	0.601
P3	0.676	C3	0.444	R3	0.538	I3	0.444	I7	0.599
P4	0.610	C4	0.400	R4	0.546	I4	0.605	I8	0.429
P5	0.543	C5	0.498						
P6	0.736	C6	0.548						
Eigenvalues	5.729		1.541		1.241		1.220		
% of variance	23.780		6.419		5.170		5.083		
Cumulative (%)	23.780		30.289		35.459		40.542		

3.2. Confirmatory factor analysis

The confirmatory factor analysis yielded a Chi-square value of 368.454 (df=245, sig=0.00), and the goodness-of-fit indices were as: good fit index (GFI=0.911), comparative fit index (CFI=0.904, normed fit index (NFI=0.764), root mean square error of approximation (RMARE=04), and root mean square error (RMA=0.04). The results of confirmatory factor analysis are displayed in Figure 1. The preachers also computed the Pearson correlation between total score of SIS and its subscales, as presented in Table 2. The Pearson correlation values between identity science scale and its subscales ranged from 0.70 to 0.87, while the correlation between subscales ranged from 0.37 to 0.66.

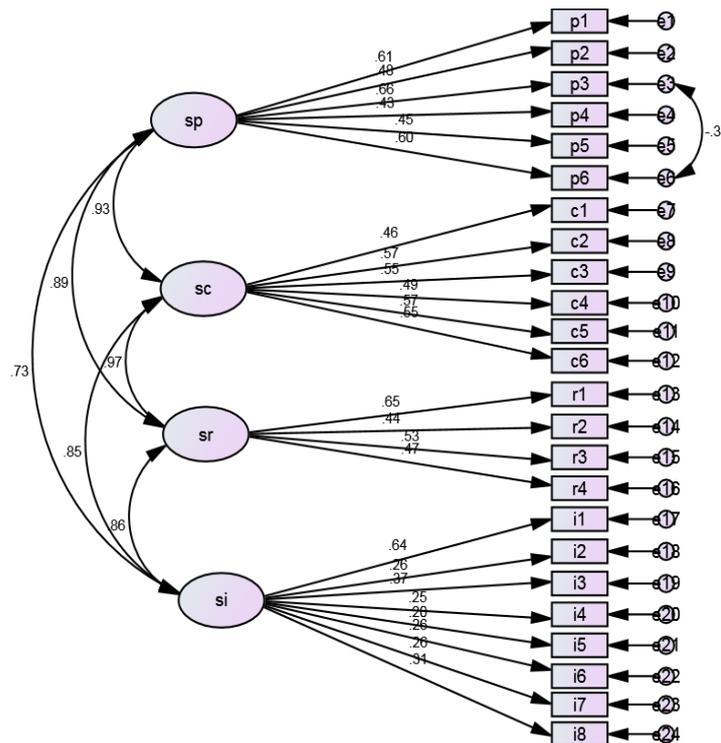


Figure 1. Confirmatory factor analysis of SIS

Table 2. Pearson correlation matrix between science identity subscales

Variables	SP	SC	SR	SI	Total score
SP	1				
SC	0.66*	1			
SR	0.56*	0.62*	1		
SI	0.37*	0.45*	0.42*	1	
Total score	0.83*	0.87*	0.78*	0.70*	1

*sig=0.01; SP=science performance; SC=science competence; SR=science recognition; SI=science interest

3.3. Reliability analysis

SIS reliability using Cronbach's alpha: total scale=0.85, and 0.75, 0.74, 0.76, and 0.70 respectively for science performance, science competence, science recognition, and science interest. The second objective is to investigate whether there were significant differences in the level of science identity due to gender. To achieve this study, objective independent sample t-test was used, as shown in Table 3. The results of independent sample t-test showed that the mean score of the science identity and its subscales (science performance, science competence, science recognition, and science interest) was higher for female students compared to the male students.

Table 3. Results of independent sample t-test

Variables	Gender	Mean	SD	t	Sig
Science performance	Male	3.91	0.68	-4.224	0.00*
	Female	4.22	0.58		
Science competence	Male	3.89	0.66	-3.903	0.00*
	Female	4.18	0.62		
Science recognition	Male	3.90	0.71	-3.630	0.00*
	Female	4.18	0.61		
Science interest	Male	4.07	0.54	-4.536	0.00*
	Female	4.28	0.27		
Science identity	Male	3.95	0.53	-5.169	0.00*
	Female	4.22	0.36		

*sig=0.01

3.4. Discussion

Although a student's science identity is the encapsulated the implications and values of that student being a science person in a variety of classes, the final outcomes is influenced by variety of factors because not only position themselves differently in various science classes, but are also positioned differently by others in those classes, in addition to various dialogues and discussions that can influence how students' define their identities [24]. According to Barrett [25], emotions are the primary mediators in our identity and of what makes us unique in society. As a result, they are crucial in formation of our identity. Emotions are reactions to and illustrative indicators of a person possess importance and level of worth toward certain things. An identity significant or distinction is determined by its responsibility to two emotive and interactive dimensions [26]. When students' see themselves as active participants in the scientific class interacting meaningfully with their classmates', their science identity is strengthened and connections based on science identity are emotionally fulfilling.

In a science class, their presence improves both communication and emotional aspects. A students' competence and self-esteem are also developed and strengthened as a result of their involvement and comfort with using their science knowledge un the context into of the science classroom. The dynamic that solidifies the community-related identity is the acknowledgement of ability and acceptability as an insider displayed by contact which the community [16]. Firstly, the aim of the current study was to validation and readability of the SIS for high school students in Jordan. The results of the exploratory factor analysis showed that the value of KMO was 0.868. The results showed four factors loading explaining 40.542% of variance, and the value items factors from 0.40 to 0.74. Item factor loading above 0.40 is acceptable [27].

The result of the confirmatory factor analysis showed a good model fit and the goodness-of-fit were as: GFI=0.911, CFI=904, NFI=0.764, RMARE=0.04. Previous researchers [27], [28] suggested the value of the GFI above 0.80 was acceptable. Another researchers [29], [30] suggested the value of CFI range between 0.85 to 0.90 was a good fit. According to previous studies [31], [32], the value of the RMSEA ranged between 0.05 to 0.10 and was an acceptable fit.

The results of the reliability analysis for the SIS demonstrated internal consistency among the scale items. The Cronbach's alpha value for the entire scale was 0.85, and the subscales ranged between 0.70 to 0.76. According to Taber [33], a Cronbach's alpha value above 0.80 is considered a good.

The second objective of this study was to investigate whether there were significant differences in science identity based on gender. The results indicated that females' students had higher mean scores in science identity and its subscales (science performance, science competence, science recognition, and science interest) compared to male students. This suggests that females' students excel in science subjects, achieve high academic success in science, engage in science-related homework, possess the ability to comprehend scientific principle and laws, and actively seek to expand their knowledge in science subjects. According to Howard and Borgella [9], competence, performance, and recognition are key factors contributing to the development of students' science identity.

The researchers posit that the gender-based may differences in science identity may be attributed to the fact that female's students are more adept at setting and adhering to their academic goals and scientific values. They are also more capable of envisioning their role assigned in school, working diligently to master their assigned tasks, and employing effective educational strategies to achieve their academic objectives. Additionally, females' students' may be more adept at planning for their future, making academic decisions aligned with their personal ambitions, and fulfilling family expectations or the hopes and expectations of teachers and other influential individuals in their lives. This increased motivation among females students contributes to their commitment to fulfilling academic responsibilities.

Furthermore, gender differences in science identity may be attributed to the greater social support that female students receive from their families and friends compared to their male counterparts. As social support is crucial for students at this stage, it may positively influence female student interest in science subjects, consequently enhancing their science identity. Previous researchers [34], [35] have indicated that the social support provided by family and friends contributes to increased interest in science subjects among female students.

Previous studies [36], [37] have reported that males exhibit a higher level of science identity compared to females. Conversely, other studies [37], [38] have suggested that females have a lower level of science identity, especially during early adolescence. The variations in results between this study and previous ones could be attributed to cultural and sociological differences among the sample populations. In contrast, a study cited by Kaitlin *et al.* [39] in the United States found that male students had a stronger science identity compared to their female counterparts.

3.5. Limitation and recommendation

This study exclusively focused on secondary school students in government schools. Future research may benefit from including both public and private schools to provide a more comprehensive perspective. Additionally, while this study employed a self-report method for data collection using the SIS, future research may consider adopting qualitative approaches to study science identity. Moreover, exploring differences in science identity based on various demographic variables other than gender may provide valuable insights. The researchers recommend conducting comparative studies between secondary school students and university students regarding science identity, and examining the relationship between science identity and achievement goal orientations.

4. CONCLUSION

During adolescence, students undergo significant changes in various aspects of development, including such physiological, psychological, and social changes. Developing a science identity is one of the crucial changes during this phase, as students begin to explore their distinct identity, values, beliefs, and set academic and professional goals to adapt to their environment and achieve psychological and social harmony. Developing a science identity positively impacts student's self-awareness, abilities, inclinations, academic interest, and participation in educational activities, fostering academic adaptation and later professional identity. Therefore, this study aimed to examine the validity and reliability of the SIS in its Arabic version. The results confirmed that the Arabic version of the scale exhibit acceptable validity and reliability. Exploratory factor analysis revealed four factors: science performance, science competence, science recognition, and science interest within the SIS. Confirmatory factor analysis indicted a good model fit. In terms of gender, female students exhibited higher levels of science identity than their male counterparts. Differences between results of this study and previous studies may be attributed to cultural and sociological disparities among the sample populations.

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