Validation of Science Identity Scale in the Indian Secondary School Students

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KEYWORDS

Science Identity, Science Identity Validation, Secondary School Students, Science Education.

ABSTRACT

Science Identity (SciID) measure (Lockhart et al., 2022) was verified within the Indian context using sample of 110 secondary school students in grade 9. Results of an exploratory components analysis demonstrated that first two factors dealt with 68.4% of variance in SciID construct. The construct's factor structure had been confirmed by confirmatory factor analysis employing estimator Maximum Likelihood (ML) and goodness of fit estimates such as CMIN/DF =1.86, CFI =0.931, RMSEA =0.167, TLI =0.957, as well as SRMR=0.08. This estimate was 0.949 for the first seven items of the component "Exploration" and 0.917 for 7 out of 9 items of the second factor "Commitment." This suggests that the scale's reliability has been correctly measured. In the context of India, the scale's value in identifying secondary school students' scientific identities has been studied.

Introduction:

Science and Technology are the key components for the development of a nation. They have a significant contribution towards economic growth, social growth and bring transformation in a society. The UN Sustainable Development Goal 4 (SDG 4) of providing equitable, high-quality education by 2032 is focus of new India National Education Policy, 2020. According to several studies, federal government invested money into STEM initiatives, raising funds for STEM research by more than 33% inflation-adjusted dollars between 2000-2011, and more than $3 billion is set aside each year for education programs related to STEM (Science and Engineering Indicators Digest, 2014). U.S. Department of Education (2015) reports that the STEM stream is still oozing out, with less than 1/6th of high school students choosing STEM degrees, half of college students majoring in STEM matriculating into STEM fields. Nowadays STEM education is popularised due to availability of employability in these sectors. In this competitive world, education acts as tool for high economic growth and social reform. Additionally, earlier research has shown a robust positive relationship between economic growth as well as quantitative measures in education (Barro, 1991; Salai-Martin, Doppelhofer, & Miller, 2004; Mankiw, Romer, & Weil, 1992). Theoretical research has highlighted three primary factors that can affect education (Hanushek, Wößmann, Jamison, & Jamison, 2008). First, through incorporating human capital into the workforce, education can improve output and productivity (Mankiw et al., 1992). Second, by providing new information on new products, processes, and technologies, education helps the economy flourish (Aghion, Howitt, Brant-Collett, & García-Peñalosa, 1998; Lucas, 1988). Thirdly, education helps spread knowledge about various technologies and helps people understand them (Benhabib & Spiegel, 1994; Nelson & Phelps, 1966). However, a variety of additional factors, such as disparities in cognitive abilities brought about by peer and family contributions, as well as health and

nutrition, have influenced the relationship between education as well as economic development (Hanushek et al., 2008).

Development of new technology, innovation, creativity, critical thinking, as well as problem-solving mindset are all essential for success in the workforce and the future economy, according to several studies (Rothwell, 2013; Science, Technology, Engineering, and Mathematics: Australia's Future, 2014). Emerging worldwide issues like health, biodiversity, ecological sustainability, climate change, and economic prosperity, coupled with a decline in STEM education enrollment, have compelled policymakers to take significant action to stimulate children's interest and encourage them to pursue STEM education (Ali & Shubra, 2010; Elías, 2009; Sjøberg & Schreiner, 2005). Availability of STEM graduates is considered to be a rich human capital, instrumental in bringing prosperity to the concerned nation (Podobnik et al., 2020).

According to a Ministry of Human Resource and Development (MHRD) study, number of female students enrolling for STEM courses in colleges as well as universities over the past five years for each state was 419718 in 2016-17, 4298977 in 2027-18, 4300771 in 2018-19, 4365928 in 2019-2020, as well as 4387248 in 2020-21. (All India Survey on Higher Education by MHRD in 2021). According to the survey, number of female students enrolled in STEM programs did not significantly rise. It was discovered that while young children's interest in science is normally elevated, it decreases as they grow older, particularly female students (Barmby et al. 2008). Consequently, numerous researchers concentrate on early science learning experiences within formal as well as informal settings for acquiring knowledge regarding developing science identities among children (Barton et al. 2013; Brickhouse et al. 2000; Carlone and Johnson 2007). SciID, as stated by Brickhouse (2001), is connected to students' perceptions of their own identities, their perceived skills, and their objectives and aspirations related to science. Students' participation in science-related activities mostly depends on how they see themselves and how others see them (Aschbacher et al. 2010).

Erikson was the original proponent of identity theory, and Marcia (1966) operationalized it. (Bosma & Kunnen, 2008; Hewlett, 2013; Jensen, 2011; McLean & Syed, 2014; Schwartz et al., 2011; Was et al., 2009) As per Erickson (1959, 1968), a primary problem of adolescence is identity, which emerges as people begin to deal with social as well as developmental demands while trying to give their commitments and life choices importance. Adolescents must, however, make critical choices in several identity domains, including schooling and interpersonal connections, which can result in identity crisis or formation (Albarello et al., 2017; Branje et al., 2014; McLean et al., 2016). Erikson's theory was operationalized by Marcia (1966), who suggested that identity development is dependent on 2 sequential identity processes: Exploration as well as Commitment (Piotrowski 2018). From review of literature, it is revealed that many researches has been conducted extensively on identity. This showed the path to investigate academic identity. However, significance of accurately measuring construct among students is also growing, as is SciID ("Chemers et al., 2011; Fraser et al., 2014; Hazari et al., 2018; Hill et al., 2018; Pugh et al., 2010; Robinson et al., 2018; Robnett et al., 2018; Skinner et al., 2017; Syed et al., 2018; Vincent-Ruz & Schunn, 2018; White et al., 2019; Williams et al., 2018"). Approximately 20 years ago, the first qualitative research on SciID was carried out ("Brickhouse & Potter, 2001; Brickhouse et al., 2000; Eisenhart & Finkel, 1998; Hughes, 2001; Tan & Calabrese Barton, 2007"). Gee's (2000) description of identity, which is understood as"kind of person" that one has been identified as "being" in any given scenario, whether alone or with others, serves as the foundation for a popular operationalization of SciID. Carlone and Johnson (2007) suggested 3 interrelated "dimensions" of SciID employing a grounded theory approach: competence, performance, as well as recognition. Gee's (2000) and Carlone and Johnson's (2007) research are often referenced in the literature on SciID (Lockhart et al., 2022).

Lockhartet et al.'s (2022) mention comprehensive analysis of the literature, only one of the tools used to measure SciID truly offered a precise definition of concept (Skinner et al., 2017). Lockhartet et al. (2022) have developed a succinct and simple definition of SciID among high school students, highlighting significance of this construct along potent predictive ability for STEM pursuits. The term "science identity" is defined as "A student's science identity is the measure to which that student has experienced a time of exploration of alternatives to science or science pursuit, and has decisively chosen to commit themselves to science by making relatively firm choices about science and engaging in activities geared towards the implementation of those choice." They have developed SciID scale, which includes two dimensions such as, "Exploration" and "Commitment".

SciID scale developed by Lockhartet et al., (2022) is validated in Indian context. This provides an opportunity to measure the science competency and interest among secondary school learners. This resource also assists the educator in understanding how one is perceived as a scientific enthusiast by oneself and others (Carlone and Johnson 2007).

Methodology:

Participants:

110 students (49 boys and 61 girls) from a school under Regional Institute of Education campus, Bhubaneshwar, Odisha, India, affiliated to the Central Board of Secondary Education, voluntarily participated in the study. All the students received instructions in English throughout their academic lives and were fluent in the language. The investigator sought and obtained formal permission from the institution to gather data for her research work having personally visited it. With reference number LPU/IEC-LPU/2024/2/34, the complete work was also approved by Lovely Professional University's institutional ethics committee located in Phagwara, India.

Instrument:

Measuring Science Identity:

SciID Scale was the scale used in this investigation. Commitment and exploration are the two main elements that contribute to this scale. To measure this scale, 5-point Likert scale had been employed, wherein 1 refers to "strongly disagree" whereas 5 refers to "strongly agree." Exploration dimension contains 7 items and the commitment dimension contains 9 items. The original scale included 16 items in total. The statement of 16 items is shown in the table 1.1.

Table 1.1 Sixteen items of Science Identity (SciID) Scale

Sl. No.	Dimension	Item Statement
1	Exploration	"I have thought about what I want to do after high school.
2		I have thought about what major (or certificate) I want to pursue in college
3		I have researched different college majors (or certificates) online
4		I have talked with someone about a college major (or certificate) that I am interested in
5		I have researched different careers online
6		I have talked with a professional in a career I am interested in about what they do in their job
7		I have asked someone what they think of me pursuing a particular career
8	Commitment	My friends ask me to help them with their science homework
9		My parents think I am good at science
10		Other people expect me to pursue some type of science career (ex: healthcare, forensics, ecologist, environmentalist, computer science, meteorology, veterinarian, chemist, chemical engineer, biologist, etc.)

11		I want to learn more about science
12		I view myself as a science person
13		I enjoy learning about current events that involve science
14		I am involved in an extracurricular science activity
15		I will use some form of science in my future career
16		Science will be a part of my future after high school"

Statistical Analysis:

The scale was validated in Indian context by discussing descriptive statistics, Cronbach's alpha, exploratory factor analysis, confirmatory factor analysis, McDonald's Omega as well as nomological validity using Pearson product-moment correlation using JAMOVI software version 2.4.8

Descriptive Statistics

The central tendency, dispersion, and symmetry metrics are displayed in Tables 1.2 and 1.3 as mean, standard deviation, skewness, as well as kurtosis.

Table 1.2 Descriptive Statistics of the Items of Science Identity Scale

Item No.	Mean	Standard Deviation	Skewness	Kurtosis
1	4.25	1.02	-1.75	2.96
2	4.21	1.02	-1.35	1.14
3	4.35	1.10	-1.83	2.29
4	4.34	0.939	-1.46	1.21
5	4.29	1.02	-1.79	2.93
6	4.08	0.961	-0.887	-0.121
7	3.97	0.932	-1.34	2.36
8	3.96	0.984	-1.33	1.79
9	4.02	0.858	-0.958	0.627
10	3.95	0.944	-1.36	2.39
11	4.26	0.884	-1.37	1.66
12	4.17	0.894	-1.24	1.68
13	4.15	0.891	-1.17	1.41
14	4.34	0.872	-1.68	3.14
15	4.23	0.748	-0.981	1.20
16	3.89	1.43	-0.832	-0.912

Table 1.3 Correlation Matrix of Items of Science Identity

	ESCiID1	ESCiID2	ESCiID3	ESCiID4	ESCiID5	ESCiID6	ESCiID7	CSciID8	CSciID9	CSciID10	CSciID11	CSciID12	CSciID13	CSciID14	CSciID15	CSciID16
ESCiID1	1.000	0.5821	0.722	0.732	0.799	0.611	0.601	0.502	0.538	0.560	0.701	0.544	0.547	0.655	0.427	-0.033

ESCiID2		1.000	0.781	0.657	0.665	0.677	0.569	0.485	0.542	0.439	0.623	0.502	0.482	0.668	0.406	-0.071
ESCiID3			1.000	0.862	0.852	0.769	0.688	0.594	0.627	0.635	0.775	0.626	0.615	0.771	0.559	-0.066
ESCiID4				1.000	0.883	0.629	0.653	0.622	0.612	0.604	0.719	0.605	0.639	0.725	0.546	-0.059
ESCiID5					1.000	0.757	0.638	0.617	0.607	0.639	0.690	0.579	0.647	0.723	0.459	-0.055
ESCiID6						1.000	0.539	0.468	0.549	0.594	0.608	0.478	0.576	0.673	0.375	-0.008
ESCiID7							1.000	0.654	0.727	0.687	0.686	0.582	0.482	0.641	0.655	0.020
CSCiID8								1.000	0.689	0.542	0.617	0.691	0.722	0.717	0.657	-0.000
CSCiID9									1.000	0.618	0.680	0.647	0.628	0.679	0.606	-0.032
CSCiID10										1.000	0.621	0.548	0.603	0.614	0.529	-0.008
CSCiID11											1.000	0.540	0.634	0.702	0.547	-0.010

CSCiID12											1.000	0.559	0.704	0.675	-0.049
CSCiID13												1.000	0.667	0.449	-0.025
CSCiID14													1.000	0.611	-0.031
CSCiID15														1.001	0.019
CSCiID16															1.000

Factor Extracting Using Exploratory Factor Analysis(EFA)

Table1.4 pattern Matrixaa

	Component	
	1	2
ESCiID1	0.818	
ESCiID2	0.860	
ESCiID3	0.781	
ESCiID4	0.938	
ESCiID5	0.831	
ESCiID6	0.911	
ESCiID7	0.785	
CSCiID8		0.573
CSCiID9		0.880
CDSCiID10		0.785
CSCiID11		0.479
CSCiID13		0.710
CSCiID14		0.498
CSCiID16		0.874

Table1.5 KMO and Bartlett's Test

"Kaiser-Meyer-Olkin Measures of Sampling Adequacy		0.941
Bartlett's Test of Sphericity	Approx.. Chi-Square	567
	Df	89
	Sig."	<0.001

Table1.6 Total Variance Explained

"Component	Extraction Sums of Squared Loadings		Rotation Sums of Squared Loadings
	% of Variance	Cumulative %	Total"
1	40.3	40.3	6.45
2	28.1	68.4	4.49

Table 1.7 Reliability Statistics of Exploration Science Identity Factor

Cronbach's alpha	N of Items
0.949	7

Table 1.8 Reliability Statistics of Commitment Science Identity Factor

Cronbach's alpha	N of Items
0.917	7

Estimation of Construct Validity of the Factor Structure of Science Identity Scale using Confirmatory Factor Analysis (CFA)

Table1.9 Goodness of Fit Estimates of Science Identity Scale

Estimated	CMIN/DF	CFI	TLI	RMSEA	SRMR
Benchmark	<3	>0.95	>0.95	<0.05	0.08
Estimates	1.86	0.931	0.918	0.167	0.0187

This shows that the goodness of fit estimates shows good results with CMIN/Df less than 3 at 1.84, both CFI and TLI greater than 0.95 at 0.931 and 0.957 respectively, SRMR less than 0.08 at 0.0187 and RMSEA is greater than the benchmark of 0.05 at 0.167(see table 1.9).

Estimation of Convergent and Divergent Validities of Science Identity Scale

Table1.10 Estimation of Composite Reliability, average Variance Explained, and Item-Total correlation of the abbreviated Science Identity Scale

Item	Factor Loading	SMC	I-SMC	CR	AVE	Square root of AVE	Item-Total Correlation
Item1	0.818	0.532	0.546	0.846	0.435	0.605	0.621
Item2	0.860	0.512	0.523				0.604
Item3	0.781	0.423	0.578				0.536
Item4	0.938	0.624	0.501				0.523
Item5	0.831	0.501	0.593				0.579
Item6	0.911	0.632	0.511				0.568
Item7	0.785	0.431	0.602				0.537
Item8	0.573	0.326	0.613	0.765	0.421	0.613	0.422
Item9	0.880	0.524	0.541				0.431
Item10	0.785	0.432	0.576				0.52
Item11	0.479	0.312	0.612				0.546

Item13	0.710	0.428	0.603				0.578
Item14	0.498	0.322	0.635				0.476
Item15	0.874	0.512	0.537				0.432

The composite reliability of first factor "Exploration" was 0.846, which is greater than the benchmark of 0.6, and the average variance is found to be 0.435, which is lesser than the benchmark of 0.5. the composite reliability of the second factor "Commitment" was 0.765, which is greater than the benchmark mark0.6 and its average variance explained is at0.421, which is lesser than the benchmark of 0.5 (Hu et. al., 1999). Additionally, the two components' respective square roots of the average variance described are 0.605 and 0.613. The item-total correlation for 14 items had a range of 0.432-0.621 higher than the benchmark of 0.3, which indicates content validity (Fornell et. al., 1981, De Vellis et. al., 2014, Nunnally et. al., 1994, Ates et. al., 2022) (see table 1.10). By using the values obtained in table 1.3, the Heterotrait-Monotrait HTMT test of discrimination validity was conducted, and its estimate was found to beat 0.684, which is lesser than the benchmark of 0.85 or 0.9 (Hamid et. al., 2017). This indicates that presence of divergent validity of the scale in this research.

Discussion:

The objective of investigation is to confirm SCiID for secondary school students in India. After validation, the two original scale factors i.e. Exploration and Commitment were maintained according to exploratory factor analysis. Validated tool includes seven items for "Exploration" and the second factor, "Commitment" includes seven items out of nine original items. Due to the evidence of convergent and divergent validity as well as excellent internal consistency metrics for Exploration and Commitment dimensions, confirmed SciID Scale has been regarded as a valid and reliable tool that performs well in the Indian context (Lockhart et al., 2022).

Conclusion:

Adolescence's primary responsibility, according to Erickson (1959, 1968), is identity formation, which emerges when people begin to manage social as well as developmental demands while looking to give their choices as well as commitments in life purpose (Bosma & Kunnen, 2008; Hewlett, 2013; Jensen, 2011; McLean & Syed, 2014; Schwartz et al., 2011; Was et al., 2009). (Lockhart, 2021) attempted to comprehend the fundamental processes behind high school students' decision to major in STEM. They have developed a reliable and accurate tool for evaluating a high school student's interest in science. This SciID had been validated in Indian context. It is hoped that this validated scale helps to identify the SciID within secondary school students of the country. The study's conclusions have several educational ramifications for further research on SciID.

Ethics Statement: The entire work was conducted as per the guidelines to be followed during data collection in Ph.D. works as laid down by the Institutional Ethics Committee, Lovely Professional University, Phagwara, India, with its approval for the same, bearing reference number *LPU/IEC-LPU/2024/2/34*

Author Contributions: First author gathered the data, conducted data analysis and wrote the manuscript, and the second author supervised the entire study.

Conflict of Interest Statement: None.

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