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Original Article

Development and Validation of Research Instrument: Conceptual Understanding of STEM Skills Questionnaire for Achievement of Sustainable Development Goals

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Abstract

This study aimed to develop a questionnaire for assessing students' conceptual comprehension of the connection between STEM skills and the achievement of sustainable development goals across three major categories: general skills (GS), social skills (SS), and academic skills (AS). Conceptual understanding of the Stem Skills Questionnaire (CUSSQ) would be used to assess students' understanding of this relationship across three broad categories. Following a thorough literature review and focus group discussions, the tool's original version was pilot-tested with 350 students from public secondary schools. The final tool had 47 items total, each with a Likert scale of 5 points. An exploratory factor analysis (EFA) using PLS smart version 4 and a factor loading of less than 0.5 was carried out. Confirmatory Factor Analysis (CFA) was employed to evaluate the model's precision. The test results confirmed that the model is accurate and valid. The overall study's findings supported the use of the CUSSQ in assessing students' conceptual understanding and readiness for 21st-century abilities necessary for accomplishing sustainable development goals.

Keywords: Conceptual understanding, STEM educational framework, STEM instructional strategies, Sustainable development goals

INTRODUCTION

The 2015 UN Sustainable Development Goals (SDGs) safeguard the environment, stabilize the economy, and increase global well-being. SDGs envision universal peace and freedom. It authorized 230 sustainable development indicators. It will necessitate international and stakeholder cooperation to quantify and track this strategy, unlike the 60 MDG indicators (Aswirna & Ritonga, 2020). The next eight years will be used to attain these essential human and environmental health goals (Giannetti, et al., 2020). STEM education helps achieve SDGs and solve global problems. According to Hasibuan, et al., (2022), the fourth industrial revolution is merging STEM and non-STEM fields, changing our lifestyle. STEM correlates science, technology, engineering, and math. Students learn about many industries (Margot & Kettler, 2019). Future generations must be prepared to tackle complex social concerns. Pakistani professors often lack STEM skills, leaving their students unprepared for STEM employment. Use the 5-point Likert scale and Conceptual Understanding of STM Skills Questionnaire (CUSSQ). Students' SDG achievement using instructional techniques was studied in this study.

Adopting Meaningful SDGs

Thirteen of the 17 SDGs include STEM terminology. Education is essential to Goal 4, which emphasizes high-quality education. Focus on 21st-century skills 4.3, 4.4, and 4. c. Goal Eleven is STEM-related. SDG 5 and SDG 8 focus on social and economic issues and contain only one STEM-related word. Goal 17 stressed international cooperation to achieve these goals. Goals 17.6 and 17.8 of the Sustainable Development Agenda improve STEM education in poor nations.

The goals cover several global survival challenges. These goals are shared by all people, governments, corporations, and civil society (Fahmi, et al., 2022). National governments must create 2030 Agenda frameworks, programs, and activities. Technology's rapid growth requires reassessing the STEM-non-STEM balance (Nurkanti, et al., 2019). Sustainability requires environmental knowledge, moral and ethical education, and STEM. Kids learn problem-solving, critical thinking, and creativity via technology. Initiative, teamwork, and communication are promoted (Kisno, 2022). Pakistan prioritises this study. STEM achievement is promoted by provincial and national educators (Fahmi, et al., 2022). Concurrently mobilizing. Unfortunately, policymakers, educators, and academics disagree on secondary STEM class content and definitions. Also, their STEM education ideas diverge. Kasim and Ahmad (2018) found that four STEM subjects are comprehensive and provide 21st-century abilities.

STEM encourages practical problem-solving. Not like classroom sims or writing. Lifestyle is influenced by context. Applying information to personal situations enhances student engagement and learning (Hằ ng et al., 2017; Nurkanti, et al., 2019). Real-world STEM activities teach students about their communities (Sevian, et al., 2018). STEM educators may solve global issues. Consider its communal, world, and child benefits. The UN General Assembly created the 2030 Agenda in 2017 with 17 SDGs for a sustainable, peaceful, prosperous, and equitable world (Henriques & Brilha, 2017; Salden, et al., 2023). STEM-focused teachers and students enjoy STEM disciplines and are more inclined to work in them (Palupi, et al., 2020). Thus, STEM majors will rise, (Salden, et al., 2023). STEM education can be inquiry-, project-, and problem-based (Al Shobaki & Naser, 2017). Unlike project-based learning, problem-based learning (PBL) stresses applying students' knowledge to real-world problems and learning new material to solve them (Retnowati, et al., 2017). Students use long-term projects to explore, study, and develop project-specific skills in project-based learning (PjBL) (Barlex, 2020). Therefore, STEM PjBL students increase teamwork and communication better than lecture students (Khurram, 2023). Analysis of numerous instruments produced by CUSSQ. AKA surveys students and educators about STEM education. Using literature reviews, researchers constructed STEM tools (Farrington, et al., 2017). A STEM student viewpoint questionnaire was also prepared (Ibrahim, et al., 2017; Maheshwari, et al., 2022) to develop a STEM bachelor's degree inquiry assessment method. This STEM survey collects student data.

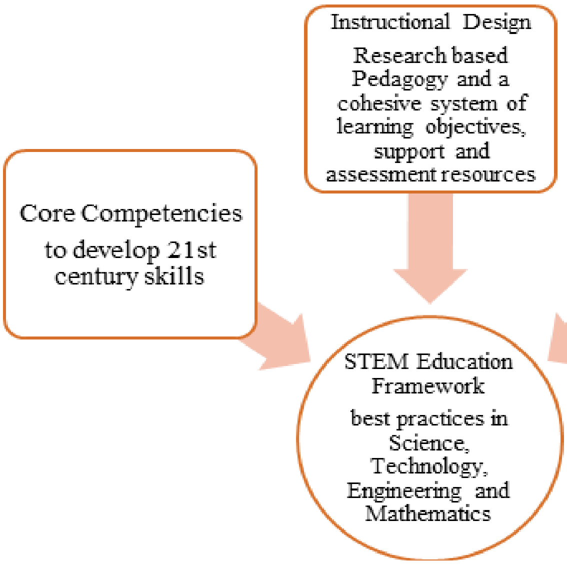

Fig. 1: STEM Education Framework

STEM Skills for the 21st Century

Higher content knowledge, academic skills, and no cognitive gifts can help undergraduates succeed (Farrington, et al., 2012). Students think more thoroughly about subjects using analytical and problem-solving skills. Time management, self-control, and study abilities don't help students learn and solve problems. Farrington, et al., (2012) say these students persevere to succeed academically. It uses worldwide best practices and cutting-edge educational research. Improved STEM abilities will equip students for modern problems. Three STEM skills are crucial for success, according to studies. Skills include:

- General Skills: Creativity, motivation, critical thinking, decision-making skills
- Social Skills: leadership skills, Communication skills, problem-solving skills, collaboration, Confidence,
- Academic Skills: related STEM subjects, Cognitive and Psychomotor Skills, use of ICT

STEM education requires 21st-century abilities like knowledge construction, real-world problem solving, effective communication, cooperation, creativity, ICT use for learning, and self-regulation. As technology promotes economic growth and innovation, many organizations and economies need STEM-skilled workers (Elmendorf et al., 2012). Despite efforts to draw more young people to these areas, several fields have skills shortages because talent supply has lagged behind demand.

- Effective communication requires the use of verbal and written tools to convey ideas in varied circumstances. Effective communication abilities become important.
- Proficiency in critical thinking and problem-solving: Assessing claims, evidence, and beliefs. Effective problem-solving methods help 21st-century people solve non-routine issues.
- ICT literacy involves using systems effectively to obtain, analyse, and share knowledge.

- To thrive in today's competitive academic and career markets, students must prioritize developing marketable life and professional skills.
- Effective teamwork improves learning and problem-solving. Learning can be self-regulated by seeing well-articulated thought processes in peer exchanges. Effective collaboration requires leadership, decision-making, rapport-building, conversation, introspection, and conflict resolution (Bjorklund, 2022).

This project promotes science graduates and math and science's economic benefits. Secondary school STEM and creative teacher development and SDG achievement are explored (Retnowati, et al., 2018). Iran has 68% math-savvy kids, below the global average. Pakistani kids score 27% on the international math test, showing low math ability. Intermediate needs are covered by 8% and high by 1%. Only 21% of Pakistani students meet the global science criterion, demonstrating a science deficit. STEM graduates should have marketable skills to get jobs in the modern economy, according to the UN Sustainable Development Goals. Now, standard teaching approaches are used. STEM-focused secondary education differs greatly from traditional techniques (Nurhasnah, et al., 2020; Maheshwari, et al., 2022). This study suggests "STEM instructional methodologies" may aid secondary pupils (Fadilah, et al., 2023). Pakistan has limited STEM and ESD research. These findings emphasize Sustainability Education and 21st-century skills. This study compared high school lesson plans and student work to 21st-century abilities.

METHODOLOGY

Due to the fluid definitions of academic skills, non-cognitive skills, and content knowledge, we used 21st-century skills like knowledge construction, real-world problem solving, skilled communication, collaboration, and use of information and communication technology for learning (Geisinger, 2016; Guo & Woulfin, 2016). THE survey assesses STEM education programs' impact on students' STEM and STEM career attitudes (Guzey, et al., 2014). See survey design in Figure 2.

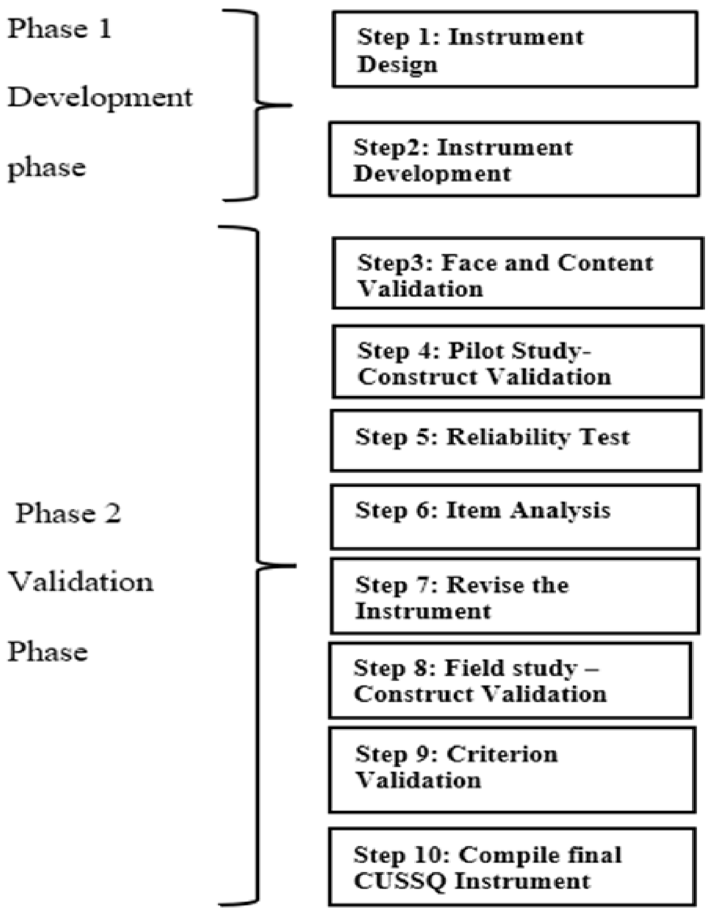

Fig. 2: Research Design of Instrument Development

Step 1: Define the Construct

Our literature investigation found traits and elements that may be updated or used to relate the concept definition to past research and concepts. After a thorough literature review, public and private secondary science instructors participated in focus groups. This activity enhanced three STEM abilities. Subfactors in this questionnaire's three areas include general, social, and academic skills.

Step2: Item Generation

CUSSQ comprises three variables and 47 items on a five-point Likert scale (Always, Often, Sometimes, Seldom/rarely, and never). CUSSQ has three variables and 47 Likert statements (Always, Often, Sometimes, Seldom/rarely, and never). One denotes never, two seldom, three occasionally, four often, and five always. To clarify the conceptual framework, we organized readings, interviews, and conversations. This completed STEM "GS" creativity, communication, and critical thinking. Second, social skills (SS) include problem-solving, collaboration, and self-confidence. STEM academic talents (AS) were third. GS had 20, SS 13, and AS 14. The questionnaire items were tailored to the study's students for comprehension.

Table 1
Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)

Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)		
Skills	Sub-factors	Items
General Skills	Creativity	1. I use a variety of methods to improve my skills.
		2. I combine ideas to create new knowledge.
		3. I can solve problems in different ways.
		4. I like to create my digital machine/modal.
		5. I imagine many things that do not exist.
		6. I find it easy to write my ideas.
		7. I can make things from recycling.
		8. My surroundings encourage me to innovate.
	Critical thinking	9. I'm eager to learn the basic concepts of the projects.
		10. I think of practical applications of new concepts.
		11. I assess the usefulness and correctness of projects.
		12. I solve new problems using experience.
		13. I put good ideas into action.
		14. I rethink a problem to understand it better.
	Motivation	15. I tolerate other people's viewpoints.
		16. Completion of one project stimulates me to start another project.
		17. I take time to understand how things work.
		18. I learn from the trial and error method.
	Communication	19. I use diagrams and charts to express my ideas.
		20. I can communicate effectively with different people.
		21. Other people can understand my ideas quickly.
		22. I consider language barriers during communications.
	Confidence	23. I confidently come up with creative ways to solve problems.
		24. I quickly discard ideas that I don't like
		25. I learn things by doing them.
		26. I explore accurate solutions
		27. I complete the project with patience.

Social Skills	collaboration	28.	Projects improve my relationships with peers.
		29.	I can integrate each science subject with technology.
		30.	I discuss ideas with peers.
		31.	Teamwork helps achieve goals.
	Real-world Problem Handling	32.	I solve problems logically and systematically.
		33.	I use my problem-solving skills to resolve problems.
		34.	I understand the role of science, technology, engineering, and mathematics in real-life problem-solving.
		35.	I collect scientific evidence to answer the problem.
		36.	I break down a problem into its simplest components.
Academic Skills	Science Technology	37.	I align scientific facts to draw concepts.
		38.	Concepts and procedures help me learn.
		39.	I help peers with an inquiry-based research project.
		40.	I use concept maps to solve problems.
		41.	To solve math problems, I use proportioning and reasoning.
	Engineering	42.	Computers help me to complete projects.
		43.	I can explain a computer program to my classmates.
		44.	I think that robotics is adequate to inter-relate different curricular contents.
		45.	I consider robotics valuable for my professional future.
	Mathematics	46.	I know that technology in the classroom impacts on students.
		47.	The use of technology is essential at all learning levels

Table 2
Detail of Items based on STEM skills

Detail of Items based on STEM skills		
S No	Factors	Number of Items
1	General Skills	20
2	Social Skills	13
3	Academic Skills	14
	Total	47

Step 3: Expert Validation of Conceptual Understanding of STEM Skills Questionnaire

A professional systematic review measures the tool's use, function, accuracy, and success to strengthen its validity. It aids sustainable development. Experts, respondents, and literature verified item substance and face validity. Thus, professionals reviewed and commented on the preliminary draft. They were told to read the form and evaluate each question for relevance, clarity, comprehensibility, plausibility, language acceptability, subject relevance, applicability, and survey value.

Step 4: Refinement of the Questionnaire

Major document changes and a new draft resulted from expert debate. The initial draft was revised after experts reviewed all questionnaire elements and questions. Early recipients included educators, Ph.D. candidates, science specialists, and NGOs' sustainability professionals. Pakistani or foreign universities employed each specialist.

Table 3
List of Panel Experts during the Questionnaire

17List of Panel Experts				
S No	Panel Expert	Designation/ Experience	Organization	Country
1	Dr. Ali Tahir	Associate Professor/ Biology	University of Cologne	Germany
2	Dr Ghada Bouillass	Research in Sustainability, life cycle	Centrale Supélec	France
3	Dr. Mohammed A. H. Al-Sharafi	Ph.D. in Management (Sustainable Development Management)	Yemen Center For Studies & Research (Sanaá University)	Yemen
4	Dr Ricardo Souza	Associate Professor /	Unesp	Brazil
5	Basim Raza	Regional integration, CARs, and South Asia	Center of Pakistan and International Relations	Pakistan
6	Dr. Furqan Tahir	Ph.D. Energy, sustainability, SDG	Hamad Bin Khalifa University	Qatar
7	Muhammad Qamar ud Din	Ph.D. Education, Specialization in Teacher Education	Federal Directorate of Education, Islamabad	Pakistan
8	Dr. Qayyum Akhtar	Ph.D. SSS Physics, MT QUED	QAED Bahawal Pur	Pakistan
9	Rashida Parveen	Ph.D.scholar	Principal	Pakistan
10	Fatima Tariq	Mphill English literature	Government College University, Lahore	Pakistan

Sustainability and STEM experts received an electronic version of the STEM Skills Questionnaire (CUSSQ) from Khawaja Fareed University of Engineering and Information Technology's Social Science Department. The researchers tested the questionnaire using multiple methods to ensure it captured the topic and measured the desired outcomes.

Step 5: Validity and Reliability Assessment

While the instrument is being developed, its content validity must be ensured, and it may contain all necessary components (Boudreau, et al., 2001) The foundation for the content validity is provided by a literature review and expert judgment.

Step 6: Face Validity, Content Validity, and Construct Validity

Measure construct relevance validities are in above table. Face validity evaluates readability, consistency, appropriateness, arrangement, comprehensibility, and language clarity. Secondary science instructors participated in focus groups for face validity. How effectively test items reflect the measure's content is substance validity. Content validity is determined by literature and experts. To confirm content validity, local and international STEM education professionals reviewed a Google document for language clarity, appropriateness, usability, and item-factor alignment. Microsoft Excel version 365 calculated 0.62 content validity ratio (CVR) for 10 experts. CUSSQ lower CVR elements were eliminated.

Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)

To ensure the high quality and reliability of the questionnaire, we calculated the Content Validity Ratio (CVR) for each item and the Content Validity Index (CVI). The CVR value of twelve (12) items was below the cut value, so these were removed from the questionnaire; the remaining thirty-five (35) items were used to form the basis of the STEM skills questionnaire (CUSSQ).

Table 4
Status of items of Conceptual Understanding of STEM Skills Questionnaire

Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)			
Item No	Statement	CVR	Status
GS1	I use a variety of methods to improve my skills.	0.94	Retained
GS2	I learn things by doing them	0.94	Retained
GS3	I like to create my digital machine/modal	0.64	Retained
GS4	I imagine many things that do not exist.	0.64	Retained
GS5	I can make things from recycling	0.74	Retained
GS6	I can make things from recycling	0.94	Retained
GS7	I use diagrams and charts to express my ideas	0.94	Retained
GS8	Completion of one project stimulated me to start another project	0.94	Retained
GS9	I take time to understand how things work	0.94	Retained
GS10	I learn from the trial and error method	0.94	Retained
GS11	I'm eager to learn about the project's main ideas	0.94	Retained
GS12	I assess the usefulness and correctness of the project	0.94	Retained
GS13	I think of practical applications of new concepts	0.94	Retained
SS1	I solve new problems using experience	0.94	Retained
SS2	I put good ideas into action	0.94	Retained
SS3	I rethink a problem to understand it better	0.94	Retained
SS4	I quickly discard ideas that I don’t like	0.94	Retained
SS5	I confidently come up with creative ways to solve problems	0.94	Retained
SS6	I explore accurate solutions	0.94	Retained
SS7	Projects improve my relationships with peers	0.88	Retained
SS8	I can integrate each science subject with technology	0.94	Retained
SS9	I discuss the ideas with peers	0.94	Retained
SS10	Teamwork helps achieve goals	0.94	Retained
SS11	I solve problems logically and systematically	0.88	Retained
SS12	I use my problem-solving skills to resolve problems	0.94	Retained
AS1	I understand the role of science, technology, engineering, and mathematics in real-life problem-solving	0.88	Retained
AS2	I align scientific facts to draw concepts	1	Retained
AS3	Concepts and procedures help me learn	1	Retained
AS4	To solve math problems, I use proportioning and reasoning	1	Retained
AS5	Computers help me to complete the projects	1	Retained
AS6	I can explain a computer program to my classmates	0.82	Retained
AS7	I think that robotics is adequate to inter-relate different curricular contents.	0.88	Retained
AS8	I consider robotics valuable for my professional future	0.82	Retained
AS9	I know that technology in the classroom impacts on students	1	Retained
AS10	The use of technology is essential at all learning levels	1	Retained

The Content Validity Ratio (CVR) for each item and the overall Content Validity Index (CVI) were calculated to assess the quality and reliability of the Conceptual Understanding of STEM Skills Questionnaire (CUSSQ).

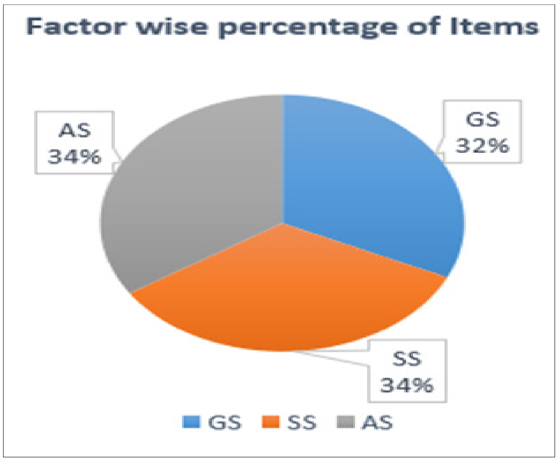

Fig. 3: Output of Percentage of items of (CUSSQ)

According to (Tang, et al., 2014), several measures of internal consistency reliability are available under CTT. These include Cronbach's alpha, (Garg et al., 2005; Meijer & Sijtsma, 2001) expected categorical variation (ECV). Most commonly employed is Cronbach's alpha. Cronbach's alpha will be used in our study to determine how reliable the instrument is with respect to its own internal consistency. The following is a textbook definition of Cronbach's alpha:

$$\alpha = \frac{k}{k-1}\left(1 - \frac{\sum_{i=1}^{k} \sigma_i^2}{\sigma_X^2}\right)$$

where α is a lower-bound estimate of the true reliability, n is the number of items in test X, σX 2 is the observed score variance of test X, and σi 2 is the variance of item i. The criteria for interpreting an internal consistency reliability coefficient of an instrument are presented in this table.

Pilot Testing of Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)

Survey data was analysed using Smart PLS 4. CUSSQ data was processed using Smart PLS version 4 to assess model fit, validity, and reliability. Pilot studies need 10-15 people per questionnaire item (Khurram, et al., 2020). The poll included 280 high school students from the research sample. Respondents offered 258 responses. Unfortunately, some students replied inaccurately. 22 sequential questions were missing. The remaining 258 respondents were assessed using Smart PLS version 4 to evaluate the scale's factor structure and discriminant validity. The below mentioned figure represent the outer model test analysis conducted through this software.

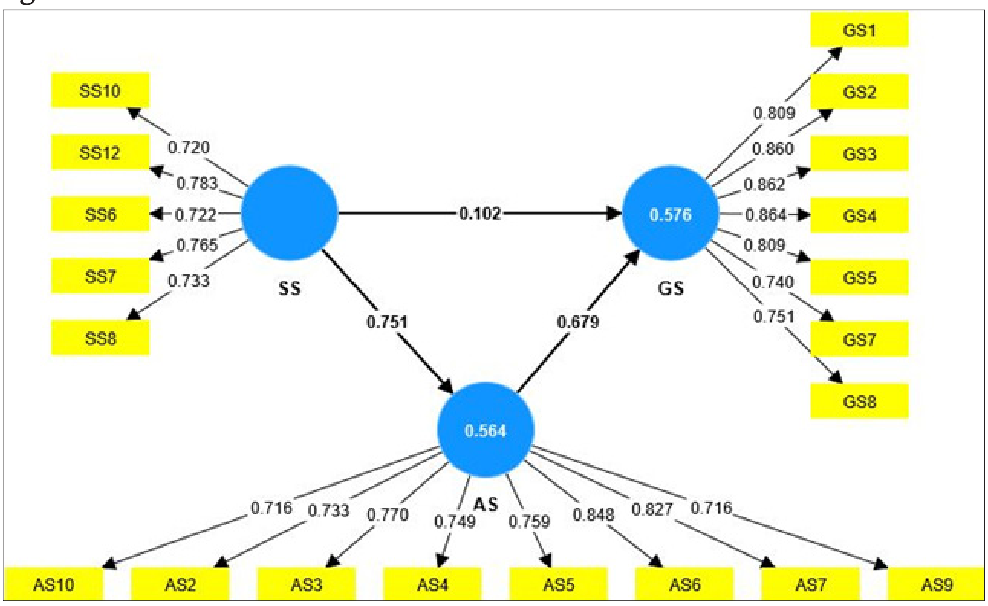

Fig. 4: Output of the Construct Model Test

All factor loadings in this model are statistically significant over 0.5, indicating instrument fit. The questionnaire deleted GS3, GS7, GS9, GS10, GS12, GS13, and GS14 from General Skills. The Social Skills elements SS1, SS2, SS3, SS4, SS5, SS9, and SS11 were likewise removed. The questionnaire no longer included Academic Skills AS1 and AS8. Factor loadings below 0.5 were removed from analysis.

Table 05

Factor Loading Values of the Conceptual Understanding of STEM Skills

Factor Loading Values of CUSST			
Item No	General Skills (GS)	Social Skills (SS)	Academic Skills (AS)
GS1	0.809		
GS2	0.860		
GS3	0.862		
GS4	0.864		
GS5	0.809		
GS7	0.740		
GS8	0.751		
SS10		0.720	
SS12		0.783	
SS6		0.722	
SS7		0.765	
SS8		0.733	
AS10			0.716
AS2			0.733
AS3			0.770
AS4			0.749
AS5			0.759
AS6			0.848
AS7			0.827
AS9			0.716

Standardized Regression Weights of items of CUSSQ

The link between independent and dependent variables can be calculated with the use of a regression model. Predicting how an independent variable will influence a dependent variable is made easier by developing a regression analysis.

Table 6

Output of Regression analysis, values of R square, F square and Standard Error

Regression analysis, values of R square, F square and Standard Error				
Model	R square	Adjusted R square	f square	Standard error
AS	0.564	0.562	0.474	0.353
GS	0.576	0.572	0.011	0.377
SS			1.294	0.447

Reliability

The reliability values of conceptual understanding of STEM skills questionnaire (CUSSQ).

Table 7
Output of Mean, Standard Deviation, and reliability Co efficient

Mean, Standard Deviation, and reliability Co efficient				
Scale	Number of statements	Mean	Standard Deviation	Reliability Coefficient
GS	7	0.813	1.000	0.679
AS	8	0.764	1.000	0.751
SS	5	0.744	1.000	0.102

Construct reliability and Convergent validity

In statistics, R-squared measures how well your model describes data. As a relationship test, it's not perfect. This hypothesis is significance-tested using the F-test. In a regression model, R-Squared (R2, the coefficient of determination) assesses how much of the dependent variable's volatility is due to independent variable changes. Rephrased, the r-squared number shows data-regression model fit.

Table 8
Output of Cronbach Alpha, composite reliability, (rh-a and rh-c) and AVE

Output of Cronbach Alpha, composite reliability, (rh-a and rh-c) and AVE				
Factors	Cronbach's alpha	Composite reliability(rho_a)	Composite reliability(rho_c)	Average variance extracted (AVE)
GS	0.899	0.901	0.919	0.587
SS	0.915	0.917	0.932	0.664
AS	0.800	0.801	0.862	0.555

Cronbach alphas for General, Social, and Academic are shown above. General skills' Cronbach alpha is 0.899. Cronbach alpha for social abilities exceeds 0.915. Academic skills exceed the 0.7 Cronbach alpha with 0.800. Over 0.7, GS, SS, and AS composite dependability (CR) scores are 0.901, 0.917, and 0.801. Composite reliability and Cronbach's Alpha exceeded 0. Hensel, et al., (2016) demonstrate tool reliability. The Cronbach Alpha coefficient should be over 0.9 for internal consistency, according to Afthanorhan et al. (2021). Good Conceptual Understanding of STEM Skills Questionnaire (CUSSQ) dependability.

Model Fit Summary of CUSSQ

The summary of model fit provides information on both the saturated model and the estimated model of questionnaire.

Table 9
Output of Model Fit Summary, Saturated Model and Estimated Model

Model Fit Summary, Saturated Model and Estimated Model		
	Saturated model	Estimated model
SRMR	0.091	0.091
d_ULS	1.721	1.721
D_G	0.845	0.845
Chi-square	1131.644	1131.644
NFI	0.711	0.711

Square the sample covariance matrix's residuals minus the hypothesised covariance model's residuals to get the standardised root mean residual. Normalised SRMR 0–1. The model fits at 0.05 or .08 (Afthanorhan et al., 2021). Statistics indicate SRMR 0.09 and NFI 0.711.

RESULT & FINDINGS

Results proved the study's instrument was valid and reliable. However, these technologies test STEM concepts. Students' STEM conceptual understanding affects their interest in STEM subjects and jobs. STEM skill interrelationships were also significant. Amazingly, Pakistan's STEM education crisis is new this year. The effects improve Pakistani science curriculum and student careers. CFA supported the Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)'s three-factor structure, corroborating the authors' conclusions. Three initial sub-factors—General skills (GS), Social skills (SS), and Academic skills (AS)—were chosen to measure 10th grade STEM skills after analyzing the research Factor analysis verified questionnaire convergent and discriminant validity. The questionnaire had 35 items. The Questionnaire and subfactors are internally consistent. Internal consistency was 0.784, showing questionnaire dependability. This instrument had 0.91 Cronbach's alpha. There is strong evidence that the Conceptual Understanding of STEM Skills Questionnaire (CUSSQ) can measure student STEM skills for sustainable development.

Discussion

This study created and tested a STEM student conceptual comprehension survey. A study verifies the STEM Skills Questionnaire's reliability and validity in measuring student conceptual knowledge. The study comprises 10th-grade science students from GGHS' low-income plan in Gulshan Usman Rahim Yar Khan. After comprehensive literature review, three subfactors emerged. 10th grade STEM tests encompass general, social, and academic skills. Then 47 questionnaire items were made. Subject matter experts verified content. After an exploratory factor analysis, questionnaire items' factor structure was studied. Factor analysis evaluated questionnaire convergent and discriminant validity. A 35-item questionnaire was obtained.

Confirmatory factor analysis validates the Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)'s three-component structure, supporting the authors' findings. Sub-factor and total questionnaire internal consistencies were good. Afthanorhan et al. (2021) observed high questionnaire internal consistency and reliability above 0.9. General talents have an above-0.7 Cronbach's alpha coefficient of 0.899. Social skills have a Cronbach alpha coefficient of 0.915, exceeding the requirement. A Cronbach alpha coefficient of 0.800 indicates intelligence over 0.7. GS, SS, and AS have composite dependability (CR) scores of 0.901, 0.917, and 0.801. Strong evidence supports the Conceptual Understanding of STEM Skills Questionnaire (CUSSQ)'s validity and reliability for testing students' STEM skills for Sustainable Development Goals.

CONCLUSION

Educational institutions are vital to STEM workforce diversity, inclusion, and equity. This is largely because they foster students' STEM passion and give them the academic background to pursue STEM jobs. Therefore, it is important to study mathematics, science, engineering, and technology, as well as their occupational profiles, such as physicists, chemists, astronomers, biological scientists, mathematicians, lab technicians, analysts, veterinarians, etc. This report encourages K-12 schools, community colleges, and universities to pursue new STEM and 21st century skills initiatives because Pakistani pupils perform lower than their international counterparts.

Competing Interest

The authors had no competing interests.

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