

NCC as a Platform for Holistic Development of Engineering Students: A Structural Equation Modeling Approach

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Abstract— This study examines the effect of National Cadet Corps (NCC) participation on the holistic development of engineering students in India, utilizing a structural equation modeling (SEM) approach. Holistic development is operationalized through four dimensions: physical, mental, emotional, and social development. Data were collected from 189 engineering students who are NCC cadets, using a structured questionnaire with validated scales. The SEM results demonstrate that NCC participation has a strong, positive, and statistically significant effect on all four developmental domains (path coefficients ranging from 0.659 to 0.706, $p < 0.001$ for all). Among these, mental development ($\beta = 0.382$, $p < 0.001$) and social development ($\beta = 0.546$, $p < 0.001$) are the most significant predictors of overall holistic development, while physical and emotional development do not show a significant direct effect when controlling for other domains. The model explains 83.7% of the variance in holistic development ($R^2 = 0.837$), indicating a robust explanatory power. The findings align with NCC's core objectives of leadership development, discipline, and social responsibility. These findings highlight the multidimensional benefits of NCC, particularly in enhancing cognitive and social competencies, and support the integration of NCC activities into engineering education to produce well-rounded graduates. The study provides empirical evidence for policymakers and educators to recognize NCC as a medium for youth development in technical institutions.

Keywords— National Cadet Corps (NCC), holistic development, engineering students, structural equation modeling (SEM), higher education, student development, co-curricular activities, Leadership training.

JEET Category— Research

I. INTRODUCTION

THE NCC is an integral component for the development of youth in India. NCC provides leadership qualities, discipline, character, physical fitness, resilience and a never-give-up spirit (Geetha & Sarkar, 2025; K. Sharma & Hooda, 2023), thus NCC inculcates principles of good conduct and army life. It also helps develop a sense of pride in oneself, pride in one's city and a sense of unity among the various regions of India (Jain & Kumar, 2021), learning for engineering students is beyond their curricula. It is also about developing other skills such as leadership, doing the right thing and working with others, so this allows engineers to solve challenging real-world problems. It also allows them to be good and make a positive impact on society (Pifer & Buckley, 2024), therefore integrating the lessons taught by NCC with the lessons taught to engineering students can improve their overall abilities. They will be able to excel in their field of study and be equipped with soft skills to work with others and lead (Geetha & Sarkar, 2025), they will have a combination of technical knowledge and essential life skills.

The National Cadet Corps (NCC) is a youth development organization in India aimed at developing character, discipline, leadership, secular outlook, spirit of adventure, and ideals of selfless service among young citizens. The core objectives of

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NCC include nation-building, leadership development, and fostering a sense of social responsibility through structured training programs, camps, and community engagement activities.

Holistic development is critical for engineering students, and the development of thinking skills, ethics, leadership, and social skills are parts of holistic development. These skills are critical for solving complex, ill-defined real-world problems (Buch, 2016; Rybinska, 2024), for adapting and creating something new, for preparing for varied career possibilities, and for making informed decisions (Drake et al., 2023; Fila et al., 2014), thus project learning and service learning have been shown to positively impact holistic development (Alves et al., 2018; Ralston & Bays, 2015). However, there is a dearth of work related to the impact of groups like the NCC on holistic development in the context of engineering programs, therefore this study could provide a basis for incorporating NCC teaching methods into the curriculum. It can also help make engineers with good skills and life skills (Wolfand et al., 2022), because engineers with such skills are highly sought after in the industry, so it is essential to focus on holistic development.

NCC develops the students in various aspects: physical, intellectual, and leadership, and it builds physique, sharpens intellect, and molds character. It toughens them for the rigors of engineering (Khatib, 2023), it provides a comprehensive development program. NCC also improves the psychological and social wellbeing of students, and it encourages teamwork and helps students manage their emotions. This creates a positive learning environment for students (Sui et al., 2024), thus making NCC beneficial for engineering students. It reduces their stress, and it also teaches them how to be good citizens (KAVRAYICI & Kesim, 2021), therefore contributing to their overall development.

II. LITERATURE REVIEW

A. Holistic Development in Education: Definition and components (physical, mental, emotional, and social development). Importance in engineering education.

Holistic education supports students in all aspects of their lives, and it supports their physical wellbeing and strength. It supports their intellectual development and problem-solving abilities, and it supports their emotional intelligence and ability to manage their feelings. It supports their social skills and ability to relate to others, and all these aspects are crucial for engineering students because they need more than technical skills (Lappay, 2024; Rybinska, 2024). They need to be able to think critically and solve complex problems, lead teams, and make ethical decisions, therefore they need to be well-rounded individuals. It just makes them a more effective worker, and it makes them a better person in an ever-changing world, thus allowing them to thrive in various environments (Kang et al., 2024; Lappay, 2024).

B. Role of NCC in Student Development: Overview of NCC activities (drills, leadership training, community service, etc.) Previous studies on NCC's impact on students.

NCC builds character in students, and it helps them develop toughness, hard work and helpfulness. NCC does this by providing physical activity, leadership training and community service, and cadets who join NCC become better human beings. They learn to work with others, communicate with others and solve problems, and research has shown that NCC builds character in students and better employees. It helps students build their personality and, in their careers, because it provides them with essential life skills, (Geetha & Sarkar, 2025). However, there has been little research on the impact of NCC on engineering students, therefore, a need to conduct more studies to understand how NCC helps engineering students in their studies and in social integration (Sharma & Hooda, 2023).

C. Structural Equation Modeling (SEM) in Educational Research: Brief explanation of SEM and its relevance. Examples of SEM applications in similar studies.

SEM is a statistical approach, and it combines factor analysis and path analysis (Крисковец, 2020). In education, SEM is widely used because it can test the relationships between student motivation, teaching, and learning. It can also correct for measurement errors (Tang & Guo, 2023), thus it is a valuable tool in this field. In engineering, SEM has explored the impact of teaching and systems thinking on engineer development (Wang, 2024), and this demonstrates that SEM can uncover underlying relationships in education. It can inform curriculum and policy development to enhance skills, including technical and interpersonal skills, therefore it is a useful approach in education. This tool helps analyze complex education problems neatly, so it supports evidence-based teaching in STEM.

D. Gaps in Literature

The lack of SEM-based research on the impact of the NCC on holistic development, and SEM is a powerful technique that has been employed in educational research to examine sophisticated relationships between constructs such as motivation, instructional quality, and learning. It has been applied in engineering education to investigate the influence of instructional approaches on professional development, because it has been found to be effective in examining complex relationships between various factors. However, it has not been employed to examine the impact of the NCC on holistic development, particularly in terms of the physical, mental, emotional, and social development of engineering students, thus highlighting the need for such studies. Such studies would provide insights into the incorporation of NCC activities into engineering curricula for the development of technical and interpersonal skills, therefore enabling educators to make informed decisions about curriculum design.

III. RESEARCH METHOD

The research design is quantitative research to understand the impact of NCC on the overall development of engineering students, and the main statistical analysis is Structural

Equation Modeling. SEM can simultaneously analyze the multiple relationships between observed variables and latent variables. It is suitable for this research, it can understand the complex relationships between physical, mental, emotional, and social development and the direct and indirect effects of NCC participation, thus providing a comprehensive analysis of the research topic. Fig shows the flowchart and research methodology used in the research. Duration of NCC participation was included as a control variable, as prolonged exposure to NCC training is expected to influence developmental outcomes.

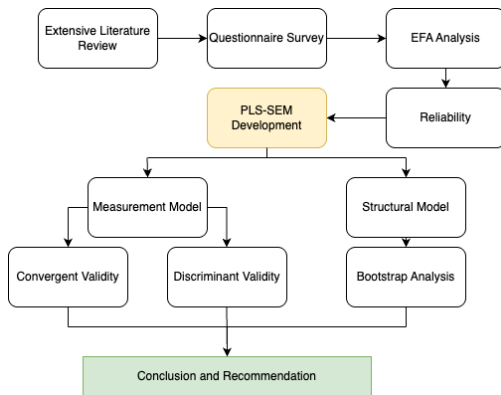


Fig. 1. Flowchart of research

A. Population and Sample

The target population will be engineering students who are NCC cadets in affiliated colleges or universities, and this population is chosen because it provides a specific group for the study. Stratified random sampling will be used, so this method will allow for the consideration of various factors. This will consider variables such as year of study, gender, and duration of NCC participation to ensure unbiased selection and representation of all relevant groups, thus providing a comprehensive overview. Sample size will be determined based on SEM analysis requirements, (Hair et al., 2017) suggest that the sample size should be at least 10 times the number of indicators in the largest construct. A minimum of 150 respondents will be targeted and this number will be used as a baseline for the study. Totally 202 respondents data was collected out of which 13 data was removed to get 189 cadets data further for analysis.

B. Data Collection

An online questionnaire will be developed through Google Forms, and the scales will be adopted from the studies mentioned above (Mondal et al., 2019). The questionnaire will be adjusted to fit the context of NCC and engineering students, and therefore, the questionnaire will consist of sections corresponding to the key constructs such as NCC participation, physical, mental, emotional, and social development. Each construct will contain several items, so the items will be measured on a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree). The items will cover the NCC participation and its impact on all aspects of development. Additional items will be included to collect demographic information, such as age, gender, year of study, and duration of NCC Participation. The survey will be

administered to a small group of NCC cadets prior to the actual study, and this will ensure that the questions are clear, valid, and reliable. Adjustments can be made based on the pilot test findings. The finalized survey will be distributed electronically through Google Forms to the selected NCC cadets who are engineering students, and thus, the survey will be made available to the target participants.

C. Data Analysis

The Smart PLS software will be used to analyze the data, Smart PLS is recommended for Partial Least Squares SEM. The first step is measurement model analysis, reliability will be assessed by cronbach's alpha and composite reliability to ensure that the measurement items are reliably estimated, and validity will be assessed by the Average Variance Extracted (AVE) for convergent validity and Fornell-Larcker criterion and cross-loadings for discriminant validity. The second step is Structural model analysis, so path analysis will be conducted to examine the relationship between NCC and holistic development dimensions, and path coefficients will be used to determine the relationship between NCC and holistic development dimensions. Bootstrapping will be conducted to test the significance of the relationships. The results will be presented in tables and path diagrams, and the analysis will provide a clear overview of the findings.

D. Ethical Considerations

Participants have been informed that their participation is voluntary, and no incentives or coercion been used to recruit participants. Participants have been assured that their responses will be kept confidential, and that data be anonymized to protect their identity; thus, they can withdraw at any time without any consequences; therefore, personal information has not been included in any reports or publications. The study has been approved by the Institutional Ethics Committee of the Vidyavardhaka College of Engineering, so it has been conducted in accordance with ethical standards, and the approval be obtained before the study begins.

IV. CONCEPTUAL FRAMEWORK

A. Proposed Model

The conceptual framework for this study, as shown in Fig. 1 is designed to examine the role of NCC participation as a catalyst for the holistic development of engineering students. The model is grounded in established theories of holistic education, social learning, and youth development and is developed through the following constructs: NCC participation, physical development, mental development, emotional development, social development, and an overarching construct of holistic development. NCC participation, the independent variable, is measured by the extent and quality of participation in NCC activities, such as drills, leadership training, and community service, and the model suggests that NCC participation has a direct positive impact on four areas of student development:

1) *Physical Development: Improvements in physical fitness, stamina, and health awareness because of regular NCC activities.*

- 2) *Mental Development: Enhancement of cognitive skills, problem-solving abilities, and mental resilience fostered by NCC training and challenges.*
- 3) *Emotional Development: Growth in emotional intelligence, self-confidence, and the ability to manage stress and emotions, cultivated through NCC experiences.*
- 4) *Social Development: Advancement in teamwork, communication, leadership, and social responsibility, developed through group activities and community engagement.*

Each of these four dimensions is conceptualized as a first-order latent variable. Collectively, they contribute to the higher-order construct of holistic development, which represents the comprehensive growth of the individual across physical, mental, emotional, and social domains. The model as shown in Fig. 1 also allows for the possibility of interrelationships among the four dimensions, recognizing that development in one area may reinforce or influence growth in others.

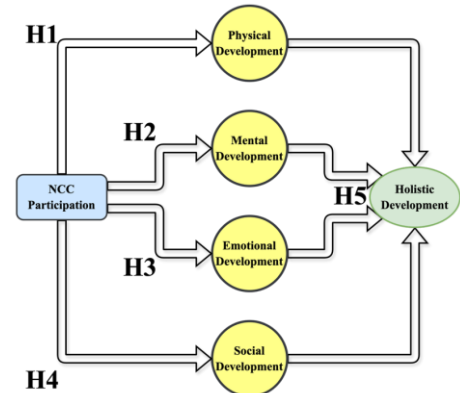


Fig. 1. Visually represents the proposed conceptual framework Hypotheses Represented in the Fig. 1

1. *H1: NCC Participation has a significant effect on Physical Development*
2. *H2: NCC Participation has a significant effect on Mental Development*
3. *H3: NCC Participation has a significant effect on Emotional Development*
4. *H4: NCC Participation has a significant effect on Social Development*
5. *H5: Physical, Mental, Emotional, and Social Development has a significant effect on Holistic Development*

The theoretical basis for the study is supported by framework by holistic education theory (Miller, 2019), social learning theory (Bandura, 1978), and empirical studies on youth development through structured extracurricular activities (Larson, 2000). This conceptual framework provides a clear and testable structure for your research, guiding both the development of your questionnaire and the subsequent SEM analysis

V. RESULTS AND ANALYSIS

A. Descriptive Statistics

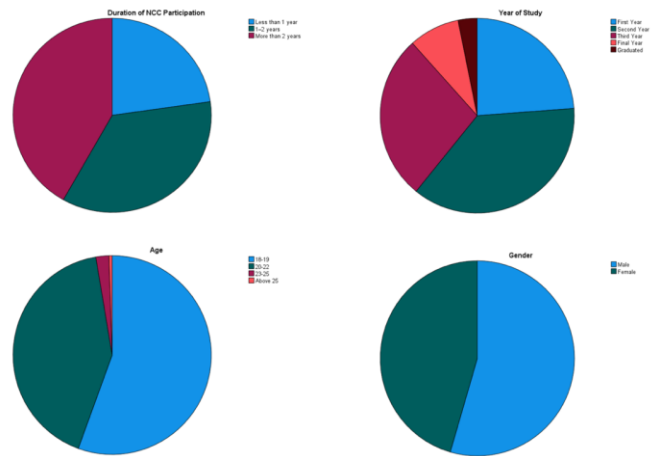
This section contains the demographic profile of the respondents as shown in Table I, and this section helps in

profiling the sample and assessing its representativeness. Demographic variables are age, gender, year of study and duration of participation in NCC are presented in tables with frequency and percentage for each category.

TABLE I
DESCRIPTIVE STATISTICS OF DEMOGRAPHIC DATA

Demographic Data	Particulars	N	%
Gender	Male	103	54.50%
	Female	86	45.50%
Age	18-19	105	55.60%
	20-22	79	41.80%
	23-25	4	2.10%
	Above 25	1	0.50%
Year of Study	First Year	45	23.80%
	Second Year	70	37.00%
	Third Year	52	27.50%
	Final Year	16	8.50%
	Graduated	6	3.20%
Duration of NCC Participation	Less than 1 year	43	22.80%
	1-2 years	67	35.40%
	More than 2 years	79	41.80%

Table I presents the demographic profile of the respondents in terms of gender, age, academic year, and duration of NCC experience in terms of frequency (N) and percentage (%), and it summarizes the demographic profile of the respondents in terms of gender, age, academic year, and NCC experience. Gender: 54.50% (103) males and 45.50% (86) females, so the distribution of males and females is thus presented. Age: 55.60% (105) 18-19 years, 41.80% (79) 20-22 years, 2.10% (4) 23-25 years, and 0.50% (1) >25 years; therefore, the age distribution is presented in these categories. Academic year: 37.00% (70) second year, 27.50% (52) third year, 23.80% (45) first year, 8.50% (16) final year, and 3.20% (6) graduated, because the respondents are thus distributed across different academic years. Duration of NCC experience: 41.80% (79) >2 years, 35.40% (67) 1-2 years, and 22.80% (43) <1 year, thus the duration of NCC experience is presented in these categories. The demographic data are also plotted as a pie chart, as shown in Graph 1.



Graph 1 Pie Chart for different demographic data

The Table II shows the number of respondents who agree with each of the statement and there are 6 main constructs.

The statement is relating to NCC Participation, physical and mental development, emotional development, social development and holistic development, the respondents are allowed to state whether they strongly disagree, disagree, do not know, agree and strongly agree. The Table II states number of people for each statement and what percentage it is, thus major points are as below: NCC Participation: 60.80% of the respondents strongly agree that they participation frequently, and 38.60 % of the respondents attend NCC camps and training. 76.70 % of the respondents strongly agree that through NCC they have learned the importance of being punctual and obeying rules, therefore this is a key aspect of NCC. Physical development majority (63.00%) strongly agree that through NCC they have become physically fit, and majority (67.70%) strongly agree that through NCC they have developed a sense of fitness and health consciousness. Majority (63.50%) strongly agree that through NCC they have become strong and flexible, so this suggests a positive impact on physical health. Psychological development majority (55.00%) strongly agree that through NCC they have developed a sense of problem solving, because majority (59.30%) strongly agree that through NCC they have developed a sense of stress management. Many (47.10%) strongly agree that through NCC they have developed a sense of concentration on studies, thus this is an important area of development. Emotional development: Strong agreement with the statement that NCC helps control feelings was expressed by 50.80%, and strong agreement with the statement that NCC makes me feel good about myself was expressed by 57.70%. Strong agreement with the statement that NCC helps me understand my feelings was expressed by 54.00%, so this suggests a positive impact on emotional well-being. Social development: Strong agreement with the statement that NCC helps me work in a group was expressed by 62.40%, because strong agreement with the statement that NCC helps me talk to and get along with others was expressed by 56.10%. Strong agreement with the statement that NCC helps me care about others was expressed by 57.70%, therefore this is an important aspect of social development. Holistic development: Strong agreement with the statement that NCC helps me develop in many ways was expressed by 58.70%, and strong agreement with the statement that NCC helps me balance school and extra-curricular activities was expressed by 49.20%. Majority (61.40%) strongly agree that NCC prepares them for life, thus this is a key benefit of NCC.

B. Measurement Model Results

A PLS-SEM model was constructed as shown in Fig. NCC Participation positively influence Physical, Mental, Emotional, and Social Development. These 4 constructs influence Holistic Development because they are interconnected with each other. The influence of NCC Participation on Physical, Mental, Emotional, and Social Development is high, positive, and significant at 0.66 to 0.71, thus indicating a strong relationship. Mental and Social Development are the most important predictors of Holistic Development; therefore, they have a greater impact on it. Physical and Emotional Development are also positively influenced by NCC Participation, however, they do not predict Holistic

Development after the other 2 constructs are controlled for, so their impact is limited.

Additionally, NCC Participation has a direct and positive impact on Holistic Development, with a path coefficient of 0.66, and the model accounts for a significant amount of variance, ranging from 44% to 50% for the four constructs and 84% for Holistic Development. The model is also deemed to be reliable and valid from Table III given high values of outer loading, Cronbach’s Alpha assesses the internal consistency of each construct. Values above 0.7 are generally considered acceptable, composite reliability Provides a more comprehensive measure of reliability. Values above 0.7 indicate good reliability, and AVE assessed using Average Variance Extracted (AVE). An AVE value above 0.5 suggests that the construct explains more than half of the variance of its indicators from Table III and the Fornell-Larcker criterion ensures that constructs are distinct from one another. Where the square root of AVE for each construct should be greater than its correlation with other constructs from Table IV, thus confirming its accuracy. Finally, the NCC Participation construct is confirmed to be a multi-dimensional construct that drives development, especially in the areas of critical thinking, teamwork, and personal development, and the findings suggest that the inclusion of NCC programs into engineering education curricula to enhance individual and collective development, because this can lead to better overall outcomes.

This section evaluates the reliability and validity of the constructs used in the study, ensuring that the measurement instruments are both consistent and accurate.

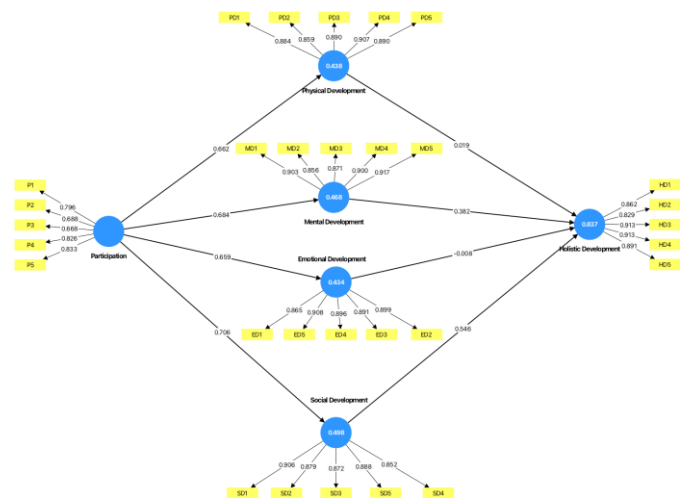


Fig. 3. The PLS-SEM analysis

The following Table III is the outer loadings of the observed variables (indicators) on their latent constructs (factors) and it indicates the strength of relationship between each observed variable and its latent construct. If the loading is 0.7 and above, it is considered adequate, therefore, the values will be used to determine the strength of the relationships (Cohen, 1992). The following is the outer loadings for the observed variables (indicators) on the latent constructs (factors), thus, the results will be presented for each construct: ED1 to ED5 has a loading between 0.865 and 0.908, and all indicators have a strong loading, because ED5 has the highest value with 0.908. HD1 to HD5 has a loading between

0.829 and 0.913, so HD3 and HD4 are the strongest factors with the loading of 0.913. MD1 to MD5 have loadings between 0.856 and 0.917, and MD5 is the strongest factor with the loading of 0.917, thus, it has the highest loading among the MD indicators. P1 to P5 have loadings between 0.668 and 0.833, and P3 is the weakest factor with the loading of 0.668, because P5 is the strongest factor with the loading of 0.833. PD1 to PD5 have loadings between 0.859 and 0.907, so PD4 is the strongest factor with the loading of 0.907, therefore, it

has the highest loading among the PD indicators. SD1 to SD5 show loadings ranging from 0.852 to 0.906, and SD1 has the highest loading of 0.906, thus, it is the strongest factor among the SD indicators. All the indicators have loadings greater than 0.7 except P3, because the highest loading is MD5 with the value of 0.917, and Participation's P3 loading is relatively small with 0.668, therefore, it is the weakest factor among all the indicators.

TABLE II
DESCRIPTIVE STATISTICS OF CONSTRUCTS AND VARIABLES

Constructs	Questionnaires	Code	N	Percentage	References	
NCC Participation	I regularly participate in NCC activities.	P1	Strongly Disagree	2	1.10%	(Bandura, 1997; Caspi et al., 2005; Stott et al., 2015)
			Neutral	10	5.30%	
			Agree	62	32.80%	
	I have attended leadership camps or training programs organized by NCC.	P2	Strongly Agree	115	60.80%	
			Strongly Disagree	6	3.20%	
			Disagree	11	5.80%	
	NCC activities have helped me develop discipline and time management skills.	P3	Neutral	26	13.80%	
			Agree	73	38.60%	
			Strongly Agree	73	38.60%	
	I actively participate in community service initiatives through NCC.	P4	Strongly Disagree	1	0.50%	
			Neutral	2	1.10%	
			Agree	41	21.70%	
	My involvement in NCC has been consistent over the years.	P5	Strongly Agree	145	76.70%	
			Disagree	2	1.10%	
			Neutral	9	4.80%	
Physical Development	NCC activities have improved my physical fitness (e.g., stamina, strength).	PD1	Agree	76	40.20%	(Kuoppala et al., 2008; PENDER et al., 1990)
			Strongly Agree	104	55.00%	
			Strongly Disagree	1	0.50%	
	I have become more aware of the importance of maintaining good health.	PD2	Neutral	3	1.60%	
			Agree	56	29.60%	
			Strongly Agree	128	67.70%	
	NCC has encouraged me to participate in physical activities outside of training.	PD3	Strongly Disagree	1	0.50%	
			Neutral	6	3.20%	
			Agree	65	34.40%	
	I feel more energetic and physically active after joining NCC.	PD4	Strongly Agree	117	61.90%	
			Disagree	1	0.50%	
			Neutral	5	2.60%	
	NCC drills and exercises have enhanced my endurance and flexibility.	PD5	Agree	62	32.80%	
			Strongly Agree	121	64.00%	
			Disagree	1	0.50%	
Mental Development	NCC has improved my ability to solve problems effectively.	MD1	Neutral	3	1.60%	(Deb et al., 2024; Pender, 1990)
			Agree	66	34.90%	
			Strongly Agree	119	63.00%	
	I feel more confident in handling stressful situations after joining NCC.	MD2	Strongly Disagree	5	2.60%	
			Neutral	9	4.80%	
			Agree	65	34.40%	
	NCC activities have enhanced my focus and concentration in academics.	MD3	Strongly Agree	112	59.30%	
			Strongly Disagree	1	0.50%	
			Disagree	1	0.50%	
	I have developed better decision-making skills through NCC training.	MD4	Neutral	14	7.40%	
			Agree	84	44.40%	
			Strongly Agree	89	47.10%	
	NCC has helped me think critically and analyze situations better.	MD5	Neutral	11	5.80%	
			Agree	76	40.20%	
			Strongly Agree	102	54.00%	
			Strongly Disagree	1	0.50%	
			Neutral	6	3.20%	
			Agree	83	43.90%	

		Strongly Agree	99	52.40%	
Emotional Development	NCC has helped me manage my emotions more effectively.	Disagree	3	1.60%	(Beverly et al., 2012; Goleman, 1996; Treglown & Furnham, 2023)
		Neutral	12	6.30%	
		Agree	78	41.30%	
		Strongly Agree	96	50.80%	
		ED1			
	I feel more confident and self-assured after participating in NCC activities.	Disagree	9	4.80%	
		Neutral	71	37.60%	
		Agree	109	57.70%	
		Strongly Disagree	1	0.50%	
		ED2			
	NCC has improved my ability to empathize with others.	Disagree	6	3.20%	
		Neutral	78	41.30%	
		Agree	78	41.30%	
		Strongly Agree	104	55.00%	
		ED3			
I have developed a positive attitude toward challenges through NCC.	Disagree	1	0.50%		
	Neutral	4	2.10%		
	Agree	67	35.40%		
	Strongly Agree	117	61.90%		
	ED4				
NCC has helped me build emotional resilience and self-awareness.	Disagree	2	1.10%		
	Neutral	7	3.70%		
	Agree	78	41.30%		
	Strongly Agree	102	54.00%		
	ED5				
Social Development	NCC has improved my ability to work effectively in a team.	Strongly Disagree	1	0.50%	(Chetty et al., 2022; Harraka, 2002; Putnam, 2000)
		Neutral	3	1.60%	
		Agree	67	35.40%	
		Strongly Agree	118	62.40%	
		SD1			
	I have developed better communication and interpersonal skills through NCC.	Strongly Disagree	1	0.50%	
		Neutral	7	3.70%	
		Agree	75	39.70%	
		Strongly Agree	106	56.10%	
		SD2			
	NCC has instilled a sense of social responsibility in me.	Neutral	5	2.60%	
		Agree	75	39.70%	
		Strongly Agree	109	57.70%	
		Strongly Disagree	1	0.50%	
		SD3			
I actively participate in community service and social initiatives through NCC.	Neutral	9	4.80%		
	Agree	81	42.90%		
	Strongly Agree	98	51.90%		
	Strongly Disagree	1	0.50%		
	SD4				
NCC has helped me build strong and meaningful relationships with others.	Neutral	4	2.10%		
	Agree	71	37.60%		
	Strongly Agree	113	59.80%		
	SD5				
	Holistic Development	NCC has contributed to my overall personal growth and development.	Disagree	2	1.10%
Neutral			6	3.20%	
Agree			70	37.00%	
Strongly Agree			111	58.70%	
HD1					
I feel that NCC has helped me balance academics and extracurricular activities.		Disagree	2	1.10%	
		Neutral	19	10.10%	
		Agree	75	39.70%	
		Strongly Agree	93	49.20%	
		HD2			
NCC has positively influenced my physical, mental, emotional, and social well-being.		Disagree	2	1.10%	
		Neutral	7	3.70%	
		Agree	67	35.40%	
		Strongly Agree	113	59.80%	
		HD3			
I believe NCC has prepared me for future challenges in life and career.	Disagree	1	0.50%		
	Neutral	3	1.60%		
	Agree	69	36.50%		
	Strongly Agree	116	61.40%		
	HD4				
NCC has played a significant role in shaping my personality.	Disagree	1	0.50%		
	Neutral	5	2.60%		
	Agree	69	36.50%		
	Strongly Agree	114	60.30%		
	HD5				

TABLE III
CONSTRUCT VALIDITY AND RELIABILITY

Path	Outer loading	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ED1 <- Emotional Development	0.865	0.936	0.937	0.951	0.796
ED2 <- Emotional Development	0.899				
ED3 <- Emotional Development	0.891				
ED4 <- Emotional Development	0.896				
ED5 <- Emotional Development	0.908				
HD1 <- Holistic Development	0.862	0.928	0.93	0.946	0.778
HD2 <- Holistic Development	0.829				
HD3 <- Holistic Development	0.913				
HD4 <- Holistic Development	0.913				
HD5 <- Holistic Development	0.891				
MD1 <- Mental Development	0.903	0.934	0.937	0.95	0.791
MD2 <- Mental Development	0.856				
MD3 <- Mental Development	0.871				
MD4 <- Mental Development	0.9				
MD5 <- Mental Development	0.917				
P1 <- Participation	0.796	0.821	0.835	0.875	0.586

P2 <- Participation	0.688				
P3 <- Participation	0.668				
P4 <- Participation	0.826				
P5 <- Participation	0.833				
PD1 <- Physical Development	0.884	0.932	0.932	0.948	0.785
PD2 <- Physical Development	0.859				
PD3 <- Physical Development	0.89				
PD4 <- Physical Development	0.907				
PD5 <- Physical Development	0.89				
SD1 <- Social Development	0.906	0.927	0.927	0.945	0.773
SD2 <- Social Development	0.879				
SD3 <- Social Development	0.872				
SD4 <- Social Development	0.852				
SD5 <- Social Development	0.888				

TABLE IV
DISCRIMINANT VALIDITY (FORNELL-LACKER CRITERION) TABLE

Construct	Emotional Development	Holistic Development	Mental Development	Participation	Physical Development	Social Development
Emotional Development	0.892					
Holistic Development	0.852	0.882				
Mental Development	0.802	0.882	0.89			
Participation	0.659	0.696	0.684	0.765		
Physical Development	0.785	0.783	0.806	0.662	0.886	
Social Development	0.907	0.811	0.811	0.706	0.845	0.879

TABLE V
PATH COEFFICIENT TABLE

Path	V	Original	Sample	Standard	T	P
	I	Value	Mean	Deviation	Statistics	Value
	F	(O)	(M)	(STD EV)	(O/ST DE V)	S
Emotional Development -> Holistic Development	7	-	-	0.093	0.08	0.935
Mental Development -> Holistic Development	7	0.382	0.375	0.105	3.653	0
Participation -> Emotional Development	1	0.659	0.664	0.066	10.002	0
Participation -> Mental Development	1	0.684	0.689	0.061	11.244	0
Participation -> Physical Development	1	0.662	0.666	0.065	10.132	0
Participation -> Social Development	1	0.706	0.709	0.059	11.896	0
Physical Development -> Holistic Development	3	0.019	0.024	0.064	0.297	0.767
Social Development -> Holistic Development	8	0.546	0.547	0.121	4.5	0
Participation -> Holistic Development	N/A	0.655	0.66	0.06	10.925	0

TABLE VI
R-SQUARE AND ADJUSTED R-SQUARE TABLE

Constructs	R-square	R-square adjusted
Emotional Development	0.434	0.431
Holistic Development	0.837	0.834
Mental Development	0.468	0.466
Physical Development	0.438	0.435
Social Development	0.498	0.495

TABLE VII
F-SQUARE (EFFECT SIZE) TABLE

Path	f-square
Emotional Development -> Holistic Development	0
Mental Development -> Holistic Development	0.122
Participation -> Emotional Development	0.767
Participation -> Mental Development	0.881
Participation -> Physical Development	0.778
Participation -> Social Development	0.992
Physical Development -> Holistic Development	0.001
Social Development -> Holistic Development	0.219

This Table III shows how good the measures are (i.e., whether they reliably measure the thing they are supposed to measure), and here is what it tells Cronbach's Alpha indicates whether the questions in each group work well together, so we like to see a score of 0.7 or above (Saboorzadeh et al., 2019). All groups score above 0.8, which is very good, because this indicates a high level of reliability, and thus Emotional and Mental Development score highest (0.936 and 0.934).

Composite Reliability (ρ_a and ρ_c) indicates whether the group as a whole works, and therefore all of them are above 0.7, which is good, and thus all of them are above 0.8, which is excellent. Emotional and Mental Development are highest (0.951 and 0.95), and thus this suggests that they are very reliable. Average Variance Extracted (AVE) is to determine how much the group explains about itself, so all of them are above 0.5 (Zhang et al., 2024), which is good, because this indicates that the group is well-defined, and therefore Emotional and Mental Development are highest (0.796 and 0.791).

Table IV shows discriminant validity was evaluated using the Fornell-Larcker criterion, a method that assesses the degree to which each construct differs from others. This criterion is satisfied when the square root of the Average Variance Extracted (AVE) for each construct (represented by bold numbers on the diagonal of Table IV) exceeds the inter-construct correlations (values found below the diagonal), indicating that each construct is measuring a unique concept. The results confirmed that this condition was met for all constructs, supporting their discriminant validity (Fornell & Larcker, 1981).

C. Structural Model Results

The PLS-SEM model in **Error! Reference source not found.** is used to examine the relationship between NCC Participation (independent variable) with Physical, Mental, Emotional and Social Development (first-order constructs) and Holistic Development (second-order construct), and the model after bootstrapping. The path coefficient and significance of the model are as follows: NCC Participation Physical Development, = 0.662 ($p = 0.000$) NCC Participation Mental Development, = 0.684 ($p = 0.000$) NCC Participation Emotional Development, = 0.659 ($p = 0.000$) NCC Participation Social Development, = 0.706 ($p = 0.000$) Physical Development Holistic Development, = 0.019 ($p = 0.767$) Mental Development Holistic Development, = 0.382 ($p = 0.000$) Emotional Development Holistic Development, = -0.008 ($p = 0.935$) Social Development Holistic Development, = 0.546 ($p = 0.000$), therefore, the R-square values of the model are as follows: Physical Development, $R^2 = 0.438$ Mental Development, $R^2 = 0.468$ Emotional Development, $R^2 = 0.434$ Social Development, $R^2 = 0.498$ Holistic Development, $R^2 = 0.837$. The measurement model can be seen in **Error! Reference source not found.**, where all the indicators (yellow boxes) show high outer loadings, thus, the path coefficients and R^2 values give the following key findings: NCC Participation has a strong, positive and significant impact on Physical, Mental, Emotional and Social Development, and Mental and Social Development are the only two first-order constructs that show significant prediction of Holistic Development. Physical and Emotional Development are insignificant in predicting Holistic Development when other developmental domains are present, because the model has strong reliability and validity with high R^2 values for Holistic Development, so the findings suggest that NCC Participation is a significant predictor of Holistic Development through Mental and Social Development. Although duration of participation was not explicitly modeled,

descriptive trends indicate that students with longer NCC involvement (>2 years) reported higher agreement levels across development indicators.

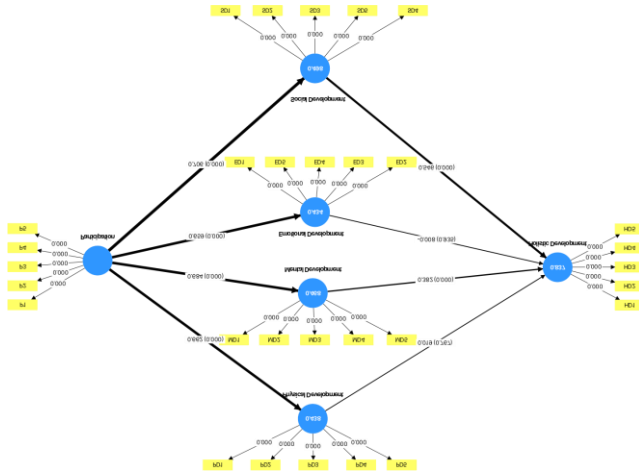


Fig. 4. Path analysis (Bootstrapping)

The path Table V helps to understand the relationships between the different dimensions of the model, and this is where the relationship is described, such as Emotional to Holistic. Path is where the relationship is described, for example, Emotional to Holistic, because this is the primary way to understand the relationships between different dimensions. Original Sample (O) is the indicator of the strength and direction of the relationship, and a positive value indicates a positive relationship, therefore, it is essential to consider the sign of the value. Sample Mean (M) is a measure of the consistency of the Original Sample; thus, it provides a way to evaluate the reliability of the data. Standard Deviation (STDEV) is a measure of the variability of the Original Sample, and a lower number is better, because it indicates that the data points are closer to the mean. T Statistics ($|O/STDEV|$) is a measure of the strength of the relationship, and a higher number is better, so it is crucial to consider this value when evaluating the relationships. P Values is a measure of whether the relationship is real, and a smaller value is better, and should be less than 0.05 (Yang & Han, 2020), therefore, it is essential to consider the p-value when determining the significance of the relationship.

From the Table V Emotional to Holistic: -0.008, P=0.935, and no relationship was found, thus, it can be concluded that there is no significant relationship between Emotional and Holistic. Mental to Holistic: 0.382, T=3.653, P=0.000, and a strong relationship in the positive direction was found, because the p-value is less than 0.05, and the t-statistic is high. Participation to Emotional: 0.659, T=10.002, P=0.000, and this indicates a strong positive relationship, therefore, it can be concluded that Participation has a significant effect on Emotional. Correlation Participation - Mental: 0.684, T=11.244, P=0.000, and this indicates a strong positive correlation, thus, it can be concluded that Participation and Mental are strongly related. Correlation Participation - Physical: 0.662, T=10.132,

P=0.000, and this indicates a strong positive correlation, because the p-value is less than 0.05, and the t-statistic is high. Correlation Participation - Social: 0.706, T=11.896, P=0.000, and this indicates a strong positive correlation, therefore, it can be concluded that Participation and Social are strongly related. Correlation Physical - Holistic: 0.019, P=0.767, and no correlation was found, thus, it can be concluded that there is no significant relationship between Physical and Holistic. Correlation Social - Holistic: 0.546, T=4.5, P=0.000, and this indicates a strong positive correlation, because the p-value is less than 0.05, and the t-statistic is high. Correlation Participation - Holistic: 0.655, T=10.925, P=0.000, and this indicates a strong positive correlation, therefore, it can be concluded that Participation and Holistic are strongly related. Participation has a **STRONG, POSITIVE EFFECT** on Emotional, Mental, Physical, Social, and Holistic, because the correlations are high, and the p-values are less than 0.05, thus, it can be concluded that Participation is a significant predictor of these dimensions. Social and Mental have a **STRONG, POSITIVE EFFECT** on Holistic, and this is because the correlations are high, and the p-values are less than 0.05, therefore, it can be concluded that Social and Mental are significant predictors of Holistic. Emotional and Physical have **NO EFFECT** on Holistic, and this is because the correlations are low, and the p-values are greater than 0.05, thus, it can be concluded that Emotional and Physical are not significant predictors of Holistic.

From Table VI R-square and R-square adjusted for constructs in the PLS-SEM model. The construct Emotional Development had an R² value of 0.434 and an R² adjusted of 0.431, and this means that the independent variable (NCC Participation) explains 43.4% of the variance of Emotional Development. The R² adjusted value of 0.431 is slightly less than the R², which gives a more accurate estimate of the R² for the population, because it considers the number of predictors and the sample size. The construct Holistic Development had an R² value of 0.837 and an R² adjusted of 0.834, and this means that the variables entered the model explain 83.7% of the variance of Holistic Development. The R² adjusted value of 0.834 is slightly less than the R², which gives a more accurate estimate of the R² for the population, thus providing a more reliable measure of the model's explanatory power. As the R² and R² adjusted values are very similar, it indicates that the independent variables in the model (Mental Development, Social Development, Physical Development and Emotional Development) are highly predictive of the dependent variable (Holistic Development), therefore suggesting a strong relationship between the variables. The construct Mental Development had an R² value of 0.468 and an R² adjusted of 0.466, and this means that the independent variable (NCC Participation) explains 46.8% of the variance of Mental Development, so the R² adjusted value of 0.466 is slightly less than the R², which gives a more accurate estimate of the R² for the population. Physical Development (R² = 0.438, Adjusted R² = 0.435): NCC Participation explained 43.8% of the variance, and the adjusted R² (43.5%) was slightly lower, indicating a satisfactory model fit, because it suggests that the model can explain a significant portion of the variance. Social Development (R² = 0.498, Adjusted R² = 0.495): NCC

Participation explained 49.8% of the variance, and the adjusted R^2 (49.5%) was slightly lower, indicating an acceptable model fit, thus providing evidence for the validity of the model.

Holistic Development had the highest R^2 and adjusted R^2 values, indicating that the model explained the greatest amount of variance, particularly from Mental and Social Development, and therefore it can be concluded that the model is highly effective in explaining the variance of Holistic Development. The adjusted R^2 values were slightly lower than the R^2 values for all constructs, as expected, because the adjusted R^2 considers the number of predictors and the sample size, providing a more accurate estimate, so it is a more reliable measure of the model's explanatory power. The R^2 values for the first-order constructs (Emotional, Mental, Physical, and Social Development) indicated that NCC Participation had a significant impact on these constructs, with the highest amount of explained variance occurring in Social Development, thus suggesting that NCC Participation is a strong predictor of Social Development.

From the Table VII f-square of the Emotional Development to Holistic Development is 0, which indicates that Emotional Development has no effect on Holistic Development, because this value shows no impact. The f-square of Mental Development to Holistic Development is 0.122, which indicates that Mental Development has a small to medium effect on Holistic Development, thus suggesting a moderate influence. The f-square of Participation to Emotional Development is 0.767, which indicates that Participation has a very large effect on Emotional Development, therefore making it a significant factor. The f-square of Participation to Mental Development is 0.881, which indicates that Participation has a very large effect on Mental Development, so it is a major contributor. The f-square of Participation to Physical Development is 0.778, which indicates that Participation has a very large effect on Physical Development, and this is consistent with its overall impact. The f-square of Participation to Social Development is 0.992, which is the largest effect in the model, and therefore Participation is the largest driver. Physical Development to Holistic Development has an f-square of 0.001, which is a negligible effect, because Physical Development has a very small effect on Holistic Development, thus having little influence. The Social Development to Holistic Development has an f-square of 0.219, which is a medium to large effect, and therefore Social Development has a good effect on Holistic Development, making it a notable factor.

Participation influences all the lower boxes (Emotional, Mental, Physical and Social Development) with very large effects, and Participation is the largest driver, because it has a significant impact on all these areas. Mental and Social Development are the only two lower boxes that have big effects on Holistic Development, while Emotional and Physical Development have little to no effect on Holistic Development.

VI. DISCUSSION

A. Overview of Findings

The structural equation model explains 83.7 % of the variance in Holistic Development, confirming the centrality of NCC participation in shaping engineering students' growth. Four hypotheses (H1–H4) concerning direct effects of NCC Participation on individual developmental domains are fully supported, while H5 is only partially supported: Mental and Social Development emerge as significant precursors of Holistic Development, whereas Physical and Emotional Development do not exert a direct effect once the other domains are controlled, it is represented in the Table VIII

TABLE VIII
HYPOTHESIS SUPPORT TABLE

Hypothesis	Path Coefficient	t-value	p-value	Supported?
H1: Participation → Physical	0.662	10.132	< 0.001	Yes
H2: Participation → Mental	0.684	11.244	< 0.001	Yes
H3: Participation → Emotional	0.659	10.002	< 0.001	Yes
H4: Participation → Social	0.706	11.896	< 0.001	Yes
H5a: Mental → Holistic	0.382	3.653	< 0.001	Yes
H5b: Social → Holistic	0.546	4.5	< 0.001	Yes
H5c: Physical → Holistic	0.019	0.297	0.767	No
H5d: Emotional → Holistic	-0.008	0.081	0.935	No

From the Table VIII A direct Participation → Holistic path ($\beta = 0.655$, $p < 0.001$) further indicates that NCC engagement fosters overall development beyond the four first-order domains.

B. Interpretation of Results

1. Physical Development (H1): Frequent drills, parades, and adventure camps significantly improve cadets' stamina, flexibility, and health consciousness (outer loadings 0.859 – 0.907). The medium R^2 (0.438) suggests that additional factors such as personal exercise habits also play a role. This reflects NCC's focus on physical fitness and endurance through structured drills and camps.
2. Mental Development (H2): NCC's problem-based tasks and leadership roles enhance critical thinking, decision-making, and stress management. With $R^2 = 0.468$ and the strongest indirect contribution to Holistic Development ($\beta = 0.382$), mental gains appear pivotal in converting disciplinary routines into broad personal growth. This aligns with NCC's objective of developing leadership and decision-making capabilities among cadets.
3. Emotional Development (H3): Although Participation strongly predicts emotional intelligence indicators (β

= 0.659), the domain does not independently drive Holistic Development once mental and social variables are included. This pattern implies a mediation effect—emotional skills may bolster teamwork or cognition rather than directly influencing holistic outcomes. This corresponds to NCC’s aim of building character and emotional resilience.

4. Social Development (H4): Group drills, service projects, and mixed-gender contingents develop interpersonal competence and civic-mindedness ($\beta = 0.706$; $R^2 = 0.498$). Social competence exerts the single largest domain-to-holistic effect ($\beta = 0.546$), confirming Putnam’s (2000) argument that structured community engagement builds social capital crucial for wider success. This supports NCC’s mission of fostering unity, teamwork, and national integration.
5. Non-significant Physical & Emotional Paths (H5c, H5d): Once mental and social gains are accounted for, purely physical or emotional benefits no longer add explanatory power. Practically, this implies that fitness and affect regulation improve students’ lives largely through better cognitive focus and prosocial behaviour.

C. Interrelationships among Domains

High latent-level correlations especially Emotional \leftrightarrow Social ($r = 0.907$) and Physical \leftrightarrow Mental ($r = 0.806$) indicate synergy. Improved affect regulation appears to underpin collaboration, while fitness supports cognitive endurance. These couplings echo holistic education model (Miller, 2019), which views learner growth as an integrated system rather than isolated competences.

D. Comparison with Previous Studies

TABLE IX
COMPARISON STUDY TABLE

Domain	Present Study	Prior Evidence
Physical gains	Strong direct effect of NCC ($\beta = 0.662$)	Matches (N. Sharma et al., 2024) on cadet fitness improvements.
Mental gains	Strongest indirect driver of holistic growth	Extends (Verma, 2021) by quantifying effect size via SEM.
Emotional gains	Significant participation effect; no direct holistic path	Differs from (Jovanović et al., 2022), suggesting cultural or sample-specific mediation.
Social gains	Largest domain-to-holistic coefficient ($\beta = 0.546$)	Reinforces (Gelderblom, 2018) social-capital thesis and (Eccles et al., 1993).

Comparison with previous studies can be seen in Table IX. Unique contributions of this research include (i) modelling NCC’s multidimensional outcomes in a single higher-order SEM, (ii) demonstrating the dominant mediating role of mental and social skills, and (iii) providing the first large-sample ($N = 189$) evidence from engineering institutions in India. The findings of this study align closely with the core objectives of NCC, particularly in fostering leadership, discipline, and social responsibility. The significant influence of mental and social development on holistic development

reflects NCC’s emphasis on cognitive resilience and collective functioning. Thus, the outcomes of this study empirically validate the foundational goals of NCC as a structured youth development program.

E. Implications for Engineering Education

NCC activities can be integrated into the engineering curriculum as credit-bearing courses or modules, aligned with modern educational practices, such as outcome-based education (OBE), and accreditation standards like ABET, because leadership camps and NCC activities can be designed to meet specific learning outcomes and rubrics for professional skills, including communication, teamwork, and ethical reasoning. A key activity is to incorporate cadet projects into design, project management, and ethics courses to provide real-world case studies, thus helping connect the dots between theory and practical application, while also promoting discipline and responsibility. A structured approach to mapping graduate attributes such as teamwork, problem solving, leadership, and civic responsibility can be directly linked to skills acquired through NCC, and it is useful to formally recognize these competencies on the students’ transcripts or e-portfolios to provide evidence of their achievement, therefore this recognition not only encourages students to participate in NCC but also enhances their employability by showcasing their varied skills. Collaboration between NCC and other campus entities can be encouraged, so for example, collaboration with entrepreneurship cells can create an environment where technical creativity is combined with disciplined execution, thus joint activities such as hackathons, innovation challenges, or community service projects can leverage the strengths of both organizations, because NCC can provide discipline, leadership, and organizational skills, while entrepreneurship cells can bring innovation and problem-solving capabilities, and this synergy can lead to the development of innovative solutions to real-world problems, thereby preparing students for complex challenges in their future careers..

F. Policy Recommendations

1. Resource Allocation: Fund on-campus, obstacle courses and leadership simulators to sustain physical and mental gains. Provide travel grants for inter-state and international NCC exchanges, amplifying social capital formation.
2. Inclusive Participation: Set gender-balanced recruitment targets and introduce flexible training slots to accommodate academic workloads, widening access to demonstrated benefits.
3. Outcome Monitoring: Mandate annual holistic-development audits using validated scales; aggregate data can guide refinement of NCC syllabi.
4. Academic-NCC Liaison Committees: Form state-level bodies linking universities, NCC Directorate, and industry to align cadet competencies with emerging labour-market needs (e.g., resilience, systems thinking).

In sum, the study confirms that active, well-structured NCC engagement is a potent vehicle for engineering students' holistic growth, predominantly through cognitive sharpening and strengthened social capital. Harnessing these insights can help educators and policymakers craft evidence-based interventions that enrich both academic programme and national youth-development agendas.

CONCLUSION

G. Summary of Findings

The purpose of this study was to investigate the effect of NCC on the holistic development of engineering students by structural equation modeling, and the findings show that the participation of NCC positively influences holistic development in different dimensions, including physical, mental, emotional, and social development. The results also suggest that mental and social development have the largest direct effect on holistic development, because physical and emotional development show positive effect from the participation of NCC, but due to their relatively lower contribution to the holistic development, they do not show significant direct effect when compared with other dimensions. In addition, the model can explain 83.7% variance of holistic development, which also shows the importance of NCC in engineering students for developing as a well-rounded and capable individual, therefore the study highlights the significance of NCC in the development of engineering students.

H. Contributions to Knowledge

This study contributes to the literature on the benefits of NCC for the holistic development of engineering students, and the study validates a multidimensional impact of NCC through SEM and demonstrates how NCC enables the development of students in multiple dimensions. The study specifically explores the development of students along psychological and social dimensions, thereby contributing to their personality development, because this exploration is essential for understanding the overall impact of NCC on students. The study also focuses on engineering students, which adds to the novelty of the study as previous studies either have not focused on engineering students or have not used such a robust methodological framework, thus making this study unique in its approach. This study validates that NCC, and other similar programs can be used as a tool for holistic development of students, where they learn technical as well as non-technical skills and build social networks, which is beneficial to them at the individual and professional levels, therefore highlighting the significance of NCC in student development.

I. Limitations

It is important to note that this study is not without limitations, and first, although the sample size is appropriate for SEM, it is relatively small, with only 189 engineering students from one geographic region. This limits the generalizability of the results to other populations and settings, because second, the cross-sectional nature of the study only

provides a snapshot of data at one point in time and does not consider the longitudinal development and/or change that may occur over the course of NCC. Third, self-reported data may also be impacted by social desirability bias, resulting in an overestimation of positive outcomes, thus the absence of a control group of non-NCC students makes it difficult to make direct comparisons and isolate the unique developmental benefits of NCC participation, therefore the study's findings should be interpreted with caution. Future studies may incorporate duration of participation as a moderating variable to better understand longitudinal effects.

J. Future Research Directions

Future research should address several issues and studies should longitudinally track students across the NCC program. This will shed more light on how the program impacts students and how long-lasting these effects are, because studies should include larger samples of students of diverse majors, schools, and locations. This will allow us to determine whether these findings generalize to other students, therefore studies should include the comparison of NCC students to non-NCC students or students involved in other clubs. This will allow us to determine what NCC specifically contributes to students, thus studies should query NCC students on their experiences. This can provide rich stories that can supplement the numbers and help us understand better how NCC helps students grow, so this will be a crucial aspect of future research.

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