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Impact of STEM-based Skilling on Psychological Well-being and Career Progression among Disadvantaged Women Demography

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ABSTRACT: This study highlights the role of STEM based skilling on career upliftment of marginalised females from Western India's Skill based University. Female education predominantly STEM education has always been trivial in marginalised communities of India. Preliminary school education is insufficient for a woman to pragmatically sustain in an economic environment for her upliftment. To empower her and make her a financially independent individual a STEM-based skill upliftment program by the said university helps marginalised females to explore job opportunities which otherwise require a regular technical and vocational education. A curriculum was designed to provide a multidisciplinary program which is a blend of mechanical engineering, electronics, and computer control along with life-skills training ensuring formal STEM education. This study highlights an empirical data set which shows a step career progression and analytical acumen towards financial responsibilities. Beyond enhancing technical competencies and employability, the study examines how participation in STEM-based skilling contributes to psychological well-being by strengthening self-confidence, self-efficacy, sense of agency, and career aspirations among underrepresented women. Before undergoing the Skill course none of the respondents contributed to domestic income or supported siblings, while post-completion, 100% contributed towards family expenses and 98.5% supported siblings financially or educationally. Statistical testing which included paired t-tests and Spearman's rank correlation have confirmed a progressive change between pre-and post-training economic indicators ($p < 0.0001$) and a strong co-relationship between savings and family contribution. These results deliver strong rational support towards Woman upliftment using STEM Education.

1. INTRODUCTION

Science, Technology, Engineering, Mathematics (STEM) education is a valuable establishment which plays a key role in the advancement of an individual in a socio-economic regime. STEM education has seen an increasing gross demand in terms of pedagogical learning. However, Gender inequalities in Science and Education has been a subject of prime concern. Woman from marginalised communities have a grim approach towards vocational education because of levies associated with such courses.

Though there is a step increase in the Woman Education in recent past but a step decline towards the preference in Technical and Vocational Education and Training (TVET) courses is observed in frugally compromised population. Also, in spite of access to education and upskilling opportunities, women always fall short in translating educational attainment into continued career advancement, particularly in technical and leadership roles Nair, V. (2023), Filandri, M., & Pasqua, S. (2025). This loophole between educational participation and occupational outcomes highlights the need to better understand how educational pathway especially skill development can contribute to women's career progression.

Presently STEM education has got a good visibility in terms of economic development, innovation, and social mobility. As per investigations STEM education finds a huge inflow of affluent and male population both (Batz-Barbarich, C., Strah, N., & Tay,

L. (2024). Woman population that to marginalised ones find it way beyond their reach. As per one school of thought STEM learning enhances problem-solving abilities, critical thinking, and employability skills (Hazari et al., 2010; Benek & Akçay, 2022). Knowledge extension with Skill based training allows one to end up with occupations with decent financial inflow with a stable and sustainable job profile. (Hill et al., 2010; García-Silva et al., 2025). To provide tangible outcomes after undertaking skill-based education is of utmost importance for career progression in female population. Although the literature focusses on women's non-representation in STEM education and early career exit, very less attention is being given on the fact of women's job progression after entering in industrial and applied STEM careers Warsame (2026), Dennehy (2017). Lack of resources and a deep understanding on how women can move from entry-level positions to supervisory or managerial roles is essential for assessing the efficiency of educational and training initiatives aimed at women's empowerment (Buyruk, B., & Korkmaz, Ö. (2016). The phenomenon identified as "leaky pipeline" wherein females take exit in their education due to household responsibilities and family pressures (Blickenstaff, 2005) can be overcome by providing skill-based education. Lack of resources and a deep understanding on how women can move from entry-level positions to supervisory or managerial roles is essential for assessing the efficiency of educational and training initiatives aimed at women's empowerment (Benek, I., & Akçay, B. (2022). Marginalised women participating in skill-based trainings and undertaking short term courses on future upcoming technologies can enhance one's professional competencies Yeboah, F. A., et al. (2023). Studies published till now on cohesive education strategies and empirical education can be transformed into enhanced workplace success.

Women in particular can be benefitted from such initiatives taken up by western India's Skill based university which provides STEM based skilling. This in turn will support their overall upliftment in advanced career temperament pertaining to career disposition.

Learning outcomes on the job training signifies an extension of formal tutoring and are increasingly familiar as a key mechanism for career advancement. Entry level jobs such as interns, trainees, or assembly-line workers should undergo rigorous trainings to get familiarised with the workplace which in turn will serve as a pathway to skill enhancement employment upgradation. However, undergoing deep skill training doesn't always assure progression in career (Heliwasnimar, & Jamilus. (2024). There are certain organisational hierarchies, promotion practices, and gender norms which have good influence on women ability to translate acquired skills into higher-level roles. If one has to enhance and achieve the desired career goals robust mentoring, continuity in education, and institutional support alongside one's strong desire can facilitate women's progression in STEM careers.

In this impact assessment study, we have undertaken career enhancement goals of marginalised female population undergoing Skill based training at Western India's Pioneering Skill Based University. Under there Woman empowerment initiative which aligns with the UNs, SDG 5 goal SDG 4 on Gender inclusivity and quality education respectively (Sujatha, S. (2024), Tamuli, P., & Mishra, K. (2023)).

By focusing on women's job progression through an educational lens, the present study aligns to the literature in three key ways. Firstly, it provides experimental indication on occupational advancement among women within a structured career-level framework. Secondly, it highlights the role of skill-intensive and technical positions as critical mid-points in women's career paths. Thirdly, it identifies ongoing gaps in progression to higher-level managerial roles, underscoring the need for continued educational and organizational support. UNESCO's Global Education Monitoring Report (2020) has highlighted about woman's fewer participation (< 30%) globally, and their participation in STEM remains consistently lower across both educational and employment pathways. These distinctions are more noticeable in rural and economically disadvantaged settings, where access to quality STEM learning, mentoring, and industry revelation is severely limited. While TVET institutions are meant to improve employability, many remain constrained by long-standing structural barriers that restrict women's full participation and success (UNESCO. (2020). Within this context, Western India's Skill based University stands out as an innovative and impactful model. The university offers industry-driven diploma programmes created specifically for respondents from remote, underserved, and socially marginalised communities across the state—respondents who are doubly disadvantaged by gender norms, geographical isolation, and socio-economic vulnerability. Keeping applied learning and employment skills in STEM-related fields on priority, Skill University provides an important involvement where gender inclusive TVET models are still limited and non-researched (Mustafa, S. A., & Altrad, A. (2026). The institute closely reflects UNESCO-UNEVOC's call for systemic reforms to strengthen gender equality in STEM-focused TVET. Importantly, University goes ahead from traditional classroom instruction by integrating mentorship, real-world industry exposure, and leadership-building opportunities

into its programme design. Till date, above 200 respondents have completed training through these specialised programmes. The UNESCO-UNEVOC publication *Boosting Gender Equality in Science and Technology: A Challenge for TVET Programmes and Careers* (2021) underlines the critical need for reforming norms for educational needs, and precisely calls for future research on the effectiveness of gender-targeted TVET interventions. It emphasises that “more research efforts should be delineated in different kinds of interventions on female participation and performance in STEM-related TVET” (UNESCO-UNEVOC, 2021). The Skill Universities noble initiative directly fills the gap, offering a relevant case study. Although women gradually dwell in technical and professional roles, their representation in managerial and decision-making positions remains strangely low (Hill et al., 2010; García-Peñalvo et al., 2022). A similar study was done to capture the nitty grit ties related to career mobility pattern in female population (Hazari et al., 2010; Lent et al., 1994).

To examine the career progression among the female employees through a Spearman’s rank- based classification for occupational advancement was used as an evaluation tool. An order was set as per the current job position and the promotional level positions acquired by the females who have undergone this skill training (Stoeger, H., (2023). This impact study analysis has helped to identify the gap between occupational advancement and STEM study as a choice in higher education. By setting up an evaluation scale for the order of career levels one could attain a structured assessment on progressive assessment in the job roles. Importantly treating this study as wholesome impact of not only career advancement but also the result of learning expertise gained in due course of the STEM training and the everyday experiences associated with it. This viewpoint focuses that STEM education outspreads beyond proper training and evolves more in workplace learning that shapes long-term career paths. Also, the gender disparities in job market remains a critical concern for all fields but predominantly TVET areas. Investigating patterns of progression can help identify where advancement slows or stagnates, thereby informing targeted interventions aimed at supporting women’s leadership development. Overall, this study aims to contribute to the global discourse on gender-responsive TVET by providing evidence from a context-specific intervention that demonstrates the potential to shift gender norms in skills training and expand women’s participation in STEM-related fields.

2. OBJECTIVES OF THE STUDY

- 1) To understand the socio-economic and structural barriers contributing to the progressive harm of marginalised woman from STEM Academic careers
- 2) To evaluate the financial upliftment in the woman who have undergone STEM Skilling program
- 3) To understand the change in the expenditure pattern and asset creation for family and self by woman who are employed after undergoing STEM Courses
- 4) To explore the career mobility in terms of job position and understand the urge towards further education in fostering career upliftment.

3. MATERIALS AND METHODS

2.1 Study Material

This study progresses with a longitudinal, mixed-methods research design to evaluate the socio-economic conversions of 135 women from marginalised communities. The research is formulated as a pre- and post-intervention with a comparative study, tracking the progression of respondents who have undergone the skill training in mechanical engineering, electronics, and computer control along with life-skills training (2019–2023), which resulted in a professional employment. A quantitative approach helped to measure the shift in objectives or life goals towards economic status, which included expenditure towards family contribution and monthly savings. These two parameters were analysed using Spearman’s Rank Correlation. The strength of the correlation acquired towards family’s economic stability and domestic investment determined the strength of the research design. This was supplemented by a qualitative component which involved detailed personal interviews and schedules to capture shifts in their expenditure pattern and saving. The survey design ensures a holistic and substantiated understanding on how skill training has effectively addressed the intergenerational dearth and resulted in economic upliftment.

2.2 Sample Collection

To ensure a wide-ranging and rigorous data analysis of the economic transition of Skill graduates, the study implemented a mixed-methods approach for data collection. Both quantitative as well as qualitative techniques were employed to capture the measurable financial outcomes and understand the fundamental socio-economic transformations experienced by the participants. The blend of in-depth interviews, structured schedules, purposive sampling, and institutional record analysis

enabled triangulation of data. This enhanced the reliability and validity of the findings. Table 1 presents a detailed overview of the data collection methods and sources used in the study.

Table 1: Data Collection Methods and Sources

Method	Description
Schedules	It was designed to evaluate the economic transition by tracking financial independence indicators such as personal bank account management, monthly savings categories, and percentage contribution to family income. These ranked variables formed the basis for Spearman's Rank Correlation analysis.
Detailed Interviews	Conducted with 135 graduates to capture qualitative dimensions of impact, focusing on shifts in household roles and socio-economic empowerment as financial contributors. Also provided insights into aspirational goals such as higher education and sibling support.
Sampling	Purposive sampling was employed to select graduates from marginalised communities who completed the skill course (2019–2023). A total of 135 respondents ensured a consistent longitudinal dataset tracking transition from dependency to employment.
Past Records	Institutional employment records and structured data extraction sheets were used to document job roles and salary progression. This verified secondary data complemented self-reported survey responses while maintaining participant anonymity.

2.3 Extraction Procedure

The study adopted a census-based approach, wherein all 135 eligible female graduates of the programme who entered formal manufacturing employment during the defined study period were included in the analysis. Since the complete eligible cohort was considered, no further sampling was undertaken. This approach enabled the study to capture the outcomes of the entire cohort.

Data were compiled from two complementary sources: programme-related records and structured questionnaires administered to the participants. Programme records were used to obtain relevant information concerning participants' programme participation, training and employment-related outcomes, while the structured questionnaires captured information on socioeconomic and psychosocial dimensions, including self-confidence, self-efficacy, career aspirations, household financial contribution, savings, sibling support and participation in household decision-making, as applicable to the study framework. The use of both documentary records and participant responses enabled the study to examine employment outcomes alongside broader socioeconomic and empowerment-related changes.

The programme was a two-year multidisciplinary skill-development programme comprising technical skill development, practical and industry-oriented training, and complementary employability and life-skills components. The programme combined structured classroom instruction with hands-on practical learning and industry-oriented training to develop technical competencies and support participants' transition into formal manufacturing employment.

2.4 Analytical methods:

The impact study done on the 135 young women who have undergone Skills training at the institute for a multidisciplinary program which is a blend of mechanical engineering, electronics, and computer control along with life-skills training. The practical and skill-based training has given them a wide exposure which they were otherwise deprived of. The target respondents were from the remotest districts of western Maharashtra state in India whose annual family income was below 5 lakhs. Offering them a curriculum which is transformative in itself and bridges the gap between quality education and industrial employment with financial perks associated with it. The study employed a combination of descriptive, index-based and inferential statistical methods to examine changes in participants' socioeconomic, empowerment, psychosocial and employment-related outcomes between the pre-programme and post-programme assessments. The Social Empowerment Index (SEI) was developed as a composite measure to capture changes across multiple dimensions of women's empowerment. The Relative Importance Index (RII) was used to determine the relative importance of the identified factors based on participants' responses. Hake's normalised

gain was applied to assess the magnitude of improvement between the pre-programme and post-programme measurements, while the Transformation Ratio was used to examine the extent of movement of participants across defined outcome categories.

2.5 Statistical Analysis

For categorical variables, the chi-square test was employed to examine whether the distribution of responses differed between the pre-programme and post-programme assessments. Effect-size measures were reported alongside statistical significance to provide an indication of the magnitude of the observed changes. Descriptive statistics were used to summarise participant characteristics and the distribution of outcome variables. Statistical significance was evaluated at the 5% significance level ($p < 0.05$).

The combination of these analytical approaches enabled the study to assess not only the direction and statistical significance of pre- and post-programme changes, but also the magnitude of improvement and the distribution of outcomes across the participant cohort. The use of multiple complementary measures was intended to provide a multidimensional assessment of the relationship between structured STEM-oriented skill development, women's empowerment, employment and socioeconomic progression.

4. RESULT AND DISCUSSION

The quantitative analysis will examine changes in participants' outcomes before and after the intervention, with particular emphasis on contribution and sibling support, as well as the relationship between savings and contribution. The analysis will be structured to assess both changes over time and associations between key variables. Descriptive statistics will first be used to summarise the characteristics and response patterns of the participants, providing a basis for interpreting the subsequent inferential analyses. The pre- and post-intervention measures will then be compared to identify the direction and magnitude of change, while correlation analysis will assess the extent to which economic factors are associated with contribution-related outcomes. Effect sizes and relevant confidence intervals will also be considered alongside statistical significance to provide a clearer understanding of the practical importance of the findings. The results will subsequently be discussed in relation to the study objectives and relevant literature, with particular attention to how changes in contribution and sibling support and the relationship between savings and contribution may contribute to understanding the broader outcomes of the intervention. The interpretation will consider both the statistical and substantive significance of the observed patterns, while recognising the contextual factors that may influence participants' responses. The analysis will also help identify whether improvements in individual outcomes are accompanied by broader changes in family or economic support. This integrated approach will allow the study to move beyond individual statistical tests and examine the broader pattern emerging from the quantitative evidence.

3.1 Socio-economic Transformation

Table 1: Descriptive Summary of Survey Variables and Responses

Sr No	Survey Variable	Response Distribution / Key Metrics
1	Asset Creation (Post-DME)	Sibling Education (48), Gadgets (43), House Remodel (17), Vehicle (13)
2	Sibling Support Status	Pre- Skill training: 0, Post Skill training:133 ((98.5%)
3	Type of Support Provided	Monetary/Fees (75), Stationary (35), Academic Guidance (30)
4	Support Recipient	Sister (57), Brother (55), Both (20)
5	Family Expense Contribution	Pre- Skill training: 0 Post Skill training:135 (100%)
6	Contribution Intensity (%)	50% (52), 40% (32), 30% (30), 60% (9), 90% (6), 20% (3)
7	Monthly Savings (INR)	>₹8,000 (53), ₹4,000–₹7,000 (52), <₹4,000 (30)
8	Strategic Saving Goals	Higher Education (120), Sibling Education (75), Marriage (30), Assets (20)
9	Financial Formalization	Bank Account Ownership: 100% (n=135)

The variables as mentioned in Table 1 were carefully chosen for the study to overcome the traditional wage employment metrics and instead emphasize on a wider socio-economic awareness among the respondents. By including variables such as sibling education support along with assets creation in the survey questionnaire a broader framework was evaluated which integrated as a multiplier effect of Skill course. The economic accomplishment of a women in family resulted as a catalytic agent for wealth creation and capital investment for the younger generations. Additionally saving goals and financial literacy (ownership of bank account and asset creation) were included to evaluate the transition from meeting the basic survival goals to proactively managing the created wealth for financial stability. These variables have created a holistic view on understanding the efficacy of specialised Skills training which enabled the respondents to do better as compared to their parentages. This data helps to understand the vertical mobility of the respondents. The findings reveal a deep insight into the socio-economic revolution among the respondents after completion of the Skill Course Program. As depicted in Table 1 none on the respondents actively contributed to the domestic income previously. This confirms about their economic dependencies later getting transformed into active financial contributors (n=135) projecting a 100% increase. Likewise, the sibling support is augmented from 0% to 98.5%, depicting a wide spread transition from the household financial assistance to gaining intellectual assistance for themselves and the household. Moreover, 100% of respondents reported possession of an individual bank account, indicating complete access to the usage of financial systems. This change implies not only increased revenue generation but also a structural transposition of women within household of economic hierarchies, and transformation to independent primary or coprimary earners.

4.2 Savings Behaviour and Financial Stability

The distribution of monthly savings presented in Figure 1 indicates a notable pattern of financial saving among the respondents. A considerable proportion of participants reported saving relatively higher amounts each month, with 22.2% reporting monthly savings of ₹9,000–₹10,000, 17.0% saving ₹8,000–₹9,000, and 20.0% saving ₹4,000–₹5,000. In contrast, 28.1% of respondents reported monthly savings below ₹4,000. The concentration of respondents in the higher savings categories suggests that a substantial proportion of participants have developed the capacity to retain a portion of their income after meeting their regular financial needs. This pattern may reflect greater financial planning, prioritisation of future needs, and an increased ability to manage available financial resources. The presence of savings across different income brackets also indicates variation in participants' financial capacity, while the relatively high proportion saving ₹8,000 or more demonstrates that a meaningful segment of respondents is able to allocate a considerable share of their earnings towards future financial security. From an empowerment perspective, the ability to save regularly can provide individuals with greater financial resilience and reduce dependence on immediate household resources during periods of unexpected expenditure. However, savings levels alone should not be interpreted as a direct measure of financial literacy; rather, the observed pattern provides an important indicator of financial capacity and saving behaviour. When considered alongside the study's findings on household contribution, asset creation and financial decision-making, the savings pattern provides further evidence of the broader economic changes experienced by the respondents.

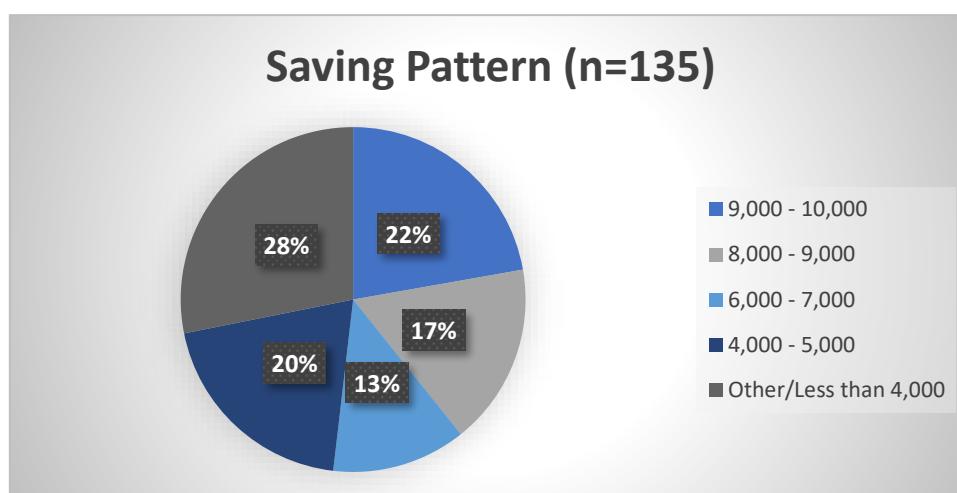


Figure 1: Distribution of Monthly savings

4.3 Household Support and Financial Impact

The examination of savings objectives (Figure 2) reveals a strong inclination for long-term, progressive financial goals. The majority of respondents reported saving for: Higher education (88.9%), Sibling education (55.6%), Marriage (22.2%), and Asset purchase (14.8%). Pre-dominance of education-related goals is indicative of a far-sighted financial mindset, where income is deliberately allocated towards improvement of future educational mobility. This aptly aligns with the wholesome objective of Skill development programmes to promote sustainable and comprehensive growth. The widespread sibling support rate (98.5%) as can also be seen from table 1 highlights the broader social impact of the programme. Savings behaviour seen in Figure 2 is strongly future-oriented and developmental. The outstanding preference for higher education (88.9%) indicates progression towards long lasting human capital investment. Additionally, 55.6% supporting sibling education reflects intergenerational social and financial mobility. Respondents are not only financially empowered but also contribute significantly to the educational and developmental needs of their family members.

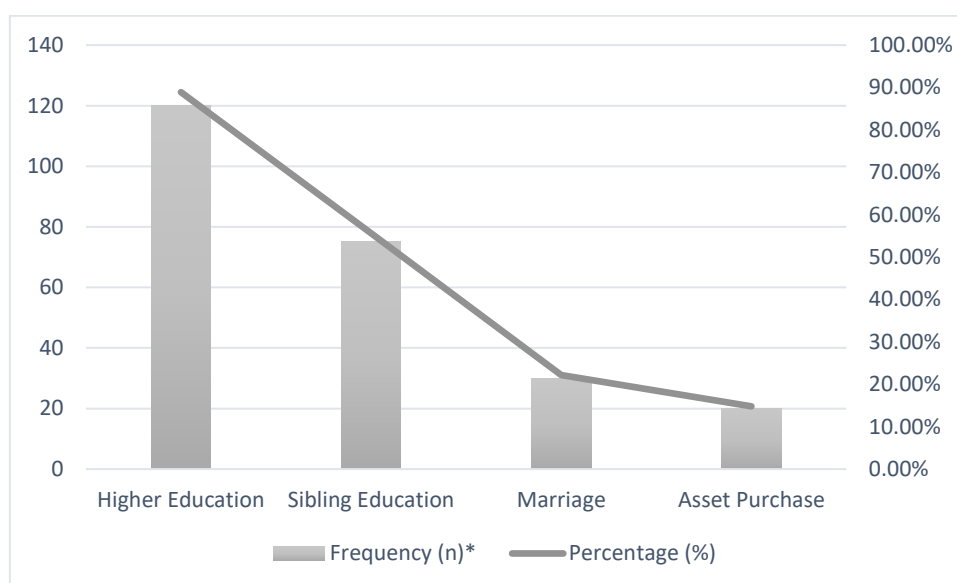


Figure 2: Primary Objectives of Monthly Savings

Table 2: Descriptive Statistics of the Economic Indicators

Statistical Metric	Family Contribution (%)	Monthly Savings (INR)	Sibling Support Rate (%)
Mean	43.85%	₹ 6,096	98.50%
Median	40.00%	₹ 5,500	100.00%
Std. Deviation	15.16%	₹ 2,689	1.20%
Minimum	20.00%	₹ 1,500	0.00%
Maximum	90.00%	₹ 9,500	100.00%

The maximum saving as depicted in the Table 2 is about ₹ 9500 which explains the improved earnings and the financial upliftment of the house hold. The planning behaviour towards the sibling's support depicts long-term economic empowerment of the family. The mean contribution level is 43.85%, and a median of 40%, indicates that many respondents contribute nearly partial earnings to household wants. The relatively high standard deviation (15.16%) suggests variability in contribution levels, likely influenced by differences in income, family structure, and financial obligations. The contribution range (20% - 90%) indicates that some respondents function as primary earners, majorly contributing towards household income.

Table 3: Statistical significance and Correlational Analysis

Analysis Type	Variable Pair	Test Statistic	P-Value	Significance
Paired t-test	Pre vs Post Contribution	$t \approx 30.5$	< 0.0001	Significant
Paired t-test	Pre vs Post Sibling Support	$t \approx 32.8$	< 0.0001	Significant
Spearman's Rank	Savings vs Contribution	$\rho \approx 0.72$	< 0.0001	Strong Positive

As can be seen from the statistical data analysis the enhanced sibling support ($p < 0.0001$), is highly significant emphasizing our conclusion about programs benefits beyond individual participation. This Skill training model generates intervention benefits which are beyond individual participation. This model indicates a ripple-effect where an individual education and professional empowerment resulted in improved outcomes for multiple family individuals specifically in the education domain. The findings are supported by the t-test results in the (Table 3) data which confirms enhanced financial contribution after undergoing the Skill course. The strong empirical evidence provides a clear insight about the Skill programs direct impact on economic upgradation of individual and overall family betterment. To strongly evaluate this as a supportive analysis the Spearman's Correlation was used to examine the responses as some datasets were non-normally distributed and some followed a logical order across various categories. Most of the data like percentage contribution and the range of savings are combined in categories and not measured on a continuous scale. Spearman's correlation being a non-parametric test is used as the dataset does not follow a standard distribution. As there are no ranked data and no normalities can be assumed in the dataset it becomes an effective technique. Its also more appropriate as it defines the correlation in survey-based datasets grouped and classified. In the current study it helps to understand if higher savings are directly correlated to higher level of financial contribution towards the family expenses without integrating any critical statistical assumptions. As can be seen from the Spearman's co-relation a linear relationship can be acquired in the variables of monthly savings and family contribution. This suggests that the individuals who have undergone Skill training have started earning more and contributing more towards household family expenses. The findings thus highlight a broad aspect of economic empowerment: An improved income outcome leads to upgraded household responsibility; by enhancing both saving capacity and familial financial contribution simultaneously. Such a relationship replicates a composed financial behaviour, where respondents manage present obligations as well as future security effectively.

4.4 Psychosocial Outcomes Following the STEM Programme

As seen from Table 4 the pre- and post-programme responses indicate a clear positive shift across the psychosocial dimensions of confidence, communication, English-speaking ability, independence and self-empowerment. Before the STEM programme, responses were predominantly concentrated in the Very Dissatisfied and Dissatisfied categories, whereas post-programme responses shifted substantially towards Satisfied and Very Satisfied. The strongest shift was observed in self-empowerment, with 100 respondents reporting Very Dissatisfied before the programme compared with 82 reporting Very Satisfied afterwards. Similarly, confidence improved from 90 respondents reporting Dissatisfied before the programme to 79 Satisfied and 48 Very Satisfied afterwards. Overall, the findings suggest that the STEM programme was associated with improvements in participants' perceived psychosocial capabilities and sense of agency, alongside their technical development. Enhanced confidence, communication and independence are particularly relevant to women's participation in formal employment and progression within technical and manufacturing-oriented careers. As these outcomes are self-reported, they are interpreted as indicators of psychosocial empowerment rather than clinical measures of psychological well-being.

Table 4: Psychosocial Outcomes Following the STEM Programme

Psychosocial Indicator	Pre-DME			Post-DME		
	Very Dissatisfied	Dissatisfied	Neutral	Neutral	Satisfied	Very Satisfied
Confidence	15	90	29	5	79	48

Communication	53	71	10	11	35	87
English-speaking	81	31	15	38	78	19
Independence	81	52	1	7	79	49
Self-empowerment	100	34	2	1	52	82

3.5 Integrated Economic and psychological Impact

When considered jointly, the findings indicate that the Skill Programme has contributed to a multidimensional improvement in the economic position of the respondents. The changes extend beyond individual income generation to include household financial contribution, support for siblings' education, savings, asset creation and participation in household financial decision-making. This suggests that the programme's economic impact is not restricted to employability but extends to participants' broader role in household economic wellbeing. The pre- and post-intervention analysis provides statistical evidence for this change. A paired-samples t-test for participants' contribution to household expenses produced a t-value of approximately 30.5 ($p < 0.0001$), indicating a statistically significant difference between the pre- and post-intervention assessments. The magnitude of the t-statistic suggests that the observed change in contribution was substantial relative to the variability in participants' responses. The transition reported among some respondents from no financial contribution before the programme to full contribution after participation provides a particularly important illustration of this change. Rather than viewing employment as an isolated individual outcome, the findings suggest that increased earning capacity translated into greater participation in household financial responsibilities. A similar pattern was observed for sibling support. The paired-samples t-test yielded a t-value of approximately 32.8 ($p < 0.0001$), demonstrating a statistically significant pre-post difference. The reported near-universal support towards siblings' education indicates that the economic benefits associated with participation may have extended beyond the individual respondent to other members of the household. Such an outcome is important from a social-development perspective because women's economic participation can generate benefits that are distributed across the family, particularly through investment in the education and development of younger household members. The impact of STEM-based skilling extends beyond employment and income generation to encompass psychological well-being, self-efficacy, and career progression. Access to relevant technical skills, employment opportunities, and career support can strengthen women's confidence, sense of agency, and ability to navigate career barriers, thereby contributing to improved psychological well-being alongside economic independence. Career progression, in turn, can reinforce perceptions of competence, financial autonomy, and social recognition, creating a mutually reinforcing pathway between economic advancement and psychological empowerment. This integrated perspective recognises that the impact of STEM skilling should not be assessed solely through income or employment outcomes, but also through improvements in confidence, career aspirations, agency, and overall well-being. The relationship between savings and contribution provides further quantitative evidence of the economic dimension of the programme. Spearman's rank-order correlation indicated a strong positive association between savings and contribution ($\rho \approx 0.72$, $p < 0.0001$). This finding suggests that respondents with stronger savings behaviour also tended to report higher levels of financial contribution. The strength of this association indicates that economic participation and financial planning may operate as interconnected dimensions rather than as independent outcomes. However, the correlation should be interpreted as an association and not as evidence that increased savings directly caused higher contribution, or vice versa.

3.5 Sustainability, Transferability and Long-Term Socioeconomic Implications

The findings suggest that the benefits of structured STEM-oriented skill development may extend beyond initial employment placement to influence women's employment continuity, income security and socioeconomic independence. The observed one-year employment retention indicates a strong degree of short-term sustainability; however, longer-term employment stability, wage progression and occupational mobility require continued follow-up. The model also demonstrates potential for transferability to other regions and institutions, particularly where comparable conditions exist in terms of industry demand, technical training infrastructure, employer linkages and access to affordable skill-based education. Nevertheless, implementation across different contexts may produce varying outcomes due to differences in regional labour markets, institutional capacity,

socioeconomic conditions and local industry ecosystems. Beyond labour-market outcomes, sustained employment and increased financial contribution may have longer-term implications for women's self-confidence, self-efficacy, career aspirations, household decision-making and socioeconomic independence. These dimensions indicate that STEM-based skilling may function not only as an employment intervention but also as a pathway towards broader social and economic empowerment. Future longitudinal and multi-institutional studies are therefore needed to establish the durability of these gains and assess the scalability of the model across diverse geographical and institutional settings.

5. CONCLUSION

The results provide strong experimental evidence that skill-based STEM training programmes, particularly in manufacturing, microelectronics with digital controls, along with life-skills training, have a transformational impact on the economic empowerment of marginalised women. The statistically significant enhancements in income contribution, investment behaviour, and inter- and intra-household support highlight the effectiveness of strategically designed course frameworks in promoting financial independence and social agency. Additionally, the strong association between savings and income contribution underlines the development of responsible financial behaviour among respondents. These findings demonstrate critical statistical validation ($p < 0.0001$) across key indicators following the completion of vocational skill education, highlighting the role of STEM-based skilling in driving comprehensive economic development and strengthening household resilience. Beyond the economic outcomes, the programme also contributes to psychological well-being by strengthening participants' self-confidence, perceived self-efficacy, sense of agency, and optimism towards their future career and livelihood opportunities. Increased financial autonomy and participation in household decision-making may further reinforce a sense of personal control, dignity, and social recognition. These dimensions suggest that the benefits of skill-based STEM education extend beyond employment and income generation to encompass psychological empowerment and improved capacity to make informed decisions about personal, professional, and household futures. Overall, the results indicate that the programme not only facilitates employment but also nurtures holistic economic and psychological empowerment, improved resource allocation, greater financial independence, and long-term planning centred on sustainable income generation and enhanced well-being.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICS STATEMENT

The organisation in which the respondents are currently employed were contacted first for their consent and the data set were curated in the form of participation which was based on organizational consent, and all data were analysed in aggregated form to create a combined questionnaires related to career progression which ensured complete confidentiality. No personal information related to their identity, contact details and location was included in the analysis.

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