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Research paper

Teachers' Perceptions of STEM Integration in Israeli Technological Education

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ABSTRACT

This article reports an exploratory quantitative field survey of teachers' perceptions of STEM integration in Israeli technological education. The study analyzed 589 complete questionnaire responses from in-service teachers who participated in a programme-linked STEM and technological education context. The questionnaire examined pedagogical perceptions, engagement and motivation, innovative pedagogy, future readiness, implementation-related perceptions, and strategic support for STEM integration. After psychometric screening, these dimensions were treated as exploratory composites rather than validated latent constructs. The final measurement model showed acceptable to excellent internal consistency (Cronbach's alpha = .75-.91), after Q16 was removed from the future-readiness composite and Q22 was reverse-coded according to its original negative wording. Descriptive findings indicated stronger endorsement of classroom-proximal dimensions, particularly engagement and innovative pedagogy, than of broad future-readiness claims. Group differences were observed across age, teaching experience, and academic qualification, but interpretation is bounded by the non-probability, programme-linked sampling frame. Welch ANOVA and Games-Howell comparisons were used where variance homogeneity was violated. Hierarchical regression with dummy-coded demographic controls showed strong within-questionnaire associations between strategic support for STEM and both innovative pedagogy and implementation-related perceptions. The negative adjusted coefficient for future readiness was interpreted as a suppression pattern under substantial overlap with implementation-related perceptions, not as a substantive negative relationship. The findings suggest that teacher support for STEM depends less on reform rhetoric alone and more on whether STEM is experienced as pedagogically usable, professionally credible, and organizationally feasible in school practice.

Keywords: integrated STEM, technological education, teacher perceptions, exploratory composites, future readiness, implementation-related perceptions, Israel

Integrated STEM education has become a central reform language in education systems seeking to prepare students for technological, social, and labor-market change. Contemporary policy documents emphasize creativity, collaboration, problem solving, adaptability, digital competence, and the ability to mobilize knowledge in unfamiliar contexts (OECD, 2018, 2023; UNESCO, 2024a, 2024b; World Economic Forum, 2025). Yet the practical meaning of STEM integration remains contested. Across systems, STEM may refer to coordinated disciplinary teaching, engineering design, project-based learning, technological literacy, computational thinking, or broader future-oriented competence development (Li et al., 2020a; Martín-Páez et al., 2019; Penchev, 2025; Portillo-Blanco et al., 2024; Takeuchi et al., 2020; Bicer et al., 2020; Tuanpusa et al., 2026).

Technological education provides a particularly important setting for examining this issue. It is one of the school domains in which abstract scientific and mathematical ideas can be connected to design, modelling, systems thinking, prototyping, and practical problem solving. Rather than treating technology as merely a tool for delivering content, current scholarship positions technological education as a domain with its own design-oriented, sociotechnical, and epistemic logic (de Vries, 2019; Pappa et al., 2024; Tytler, 2020; Wright et al., 2018; Grewe, 2025; Köşger & Görgülü, 2025).

Teacher perceptions are central to this implementation problem. STEM reforms are unlikely to become durable unless teachers interpret them as instructionally meaningful, feasible under school conditions, and credible in relation to assessment and curriculum demands. Reviews of STEM implementation repeatedly show that teachers value STEM when it supports engagement, inquiry, collaboration, and authentic learning, but they also identify time, training, resources, curricular constraints, and weak institutional support as persistent barriers (Margot & Kettler, 2019; Thibaut et al., 2019; Yu et al., 2021; Zhan et al., 2021; Webb, 2026; Uche, 2026).

Israel offers a relevant context for this inquiry because national innovation ambitions coexist with teacher-shortage pressures, sectoral variation, and uneven implementation conditions across communities and schools (Bisan Ali et al., 2025; Donitsa-Schmidt, 2025; Guberman, 2025; Sarkar, 2025). However, the present dataset does not contain school sector, region, subject specialization, or school socioeconomic variables. Accordingly, the article is framed as a programme-linked field survey rather than as a nationally representative study of Israeli teachers. The contribution is therefore empirical and exploratory: it documents how a sizeable group of practicing teachers judged multiple dimensions of STEM integration within a real implementation context.

LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

Teacher perceptions and STEM implementation

Research on integrated STEM has moved increasingly from advocacy toward implementation. Teachers' perceptions matter because teachers translate broad reform ideas into classroom tasks, assessment routines, and learning interactions. When the meaning of STEM remains ambiguous or when implementation is unsupported, teachers may endorse STEM in principle while still struggling to enact it in sustained and coherent ways (Margot & Kettler, 2019; Thibaut et al., 2019; Stevenson et al., 2026). Recent European Journal of STEM Education studies similarly emphasize the need to connect teacher perception data to concrete classroom evidence, teacher training, and implementation needs rather than treating STEM endorsement as a stand-alone outcome (Ben-Motreb, 2026; Blankendaal-Tran et al., 2026; Segarra-Morales & Rodríguez-Miranda, 2026).

A repeated finding across implementation research is that positive attitudes are not sufficient. Teachers require time, curriculum coherence, collaborative planning, resources, and professional development that is embedded in authentic school practice rather than delivered as isolated awareness sessions (Hurley et al., 2024; Reinholz et al., 2021; Surahman & Wang, 2023). This literature supports analysing STEM support as a multidimensional professional judgment rather than as a simple positive or negative attitude.

Technological education, innovation, and engagement

Technological education is closely aligned with the applied and design-oriented dimensions of integrated STEM. It offers opportunities for students to connect theory and practice through tangible problems, tools, prototypes, systems, and design decisions. Recent work on technology-rich STEM environments also shows that technology contributes most effectively when it is pedagogically orchestrated and connected to disciplinary sensemaking, rather than introduced as a stand-alone digital resource (Hidayat & Firmanti, 2024; Pappa et al., 2024; Uğraş et al., 2025). This systems perspective is consistent with recent work arguing that STEM integration must be understood as an interconnected curricular, pedagogical, and institutional process rather than as a set of isolated classroom activities (Morais et al., 2025; Penchev, 2025).

Engagement and motivation are especially important in teachers' evaluations of STEM. Teachers often become more willing to sustain reforms when they observe increased student participation, collaboration, creativity, and motivation. However, engagement depends on task quality, teacher guidance, and the balance between openness and structure; poorly designed integration can remain superficial even when it appears active (Brand et al., 2020; Gao et al., 2020; Jackson et al., 2021).

Future readiness and the risk of aspirational discourse

Future readiness is a central promise of STEM education, but it is also one of the most difficult dimensions to operationalise. Policy frameworks frequently link STEM to creativity, critical thinking, technological literacy, and employability-related skills (OECD, 2024, 2025; UNESCO, 2024b). Yet teachers may evaluate such claims cautiously when curriculum, assessment, training, and classroom time do not clearly support the future-oriented competencies being promoted.

For this reason, future readiness should be studied empirically rather than assumed. If future-oriented language is not translated into feasible instructional and assessment practices, it may remain symbolic. This concern is particularly relevant in programme-linked school settings, where teachers judge STEM through their direct experience of what can be implemented.

Conceptual framework and research questions

The conceptual framework guiding the study assumes that strategic support for STEM integration is associated with teachers' judgments about pedagogical value, student engagement, innovative pedagogy, future-readiness claims, and implementation-related perceptions. Because the instrument showed only partial psychometric stability, the present revision treats these domains as exploratory composites constructed for field-based analysis, not as fully validated latent variables.

The study addressed four research questions: RQ1: What descriptive response profile emerged from the STEM-technological education questionnaire? RQ2: Which exploratory composites demonstrated acceptable internal consistency after item screening? RQ3: What differences appeared across gender, age, teaching experience, and academic qualification? RQ4: Which STEM-related exploratory composites were associated with strategic support for STEM integration when demographic controls were entered appropriately?

METHOD

Design, sample, and programme context

The study used a cross-sectional quantitative survey design. The analytic dataset comprised 589 complete responses submitted by teachers in Israel between 11 and 14 April 2025. The survey was programme-linked, meaning that respondents were approached through a STEM/technological education implementation context rather than through a national probability sample. The programme is not named in the manuscript in order to preserve institutional anonymity and comply with the conditions under which the de-identified dataset was made available for analysis. This limits external validity, but it also gives the study value as a field-based account of teacher judgment within an authentic implementation environment.

Women represented 80.0% of the respondents (n = 471) and men 20.0% (n = 118). Age was concentrated in the middle-career range: 14.1% were under 30, 23.8% were 30-40, 53.5% were 41-50, and 8.7% were over 50. Teaching experience was also high: 57.6% reported more than ten years of teaching. Academic qualifications were predominantly at master's level (70.8%), with smaller proportions holding bachelor's degrees, diploma qualifications, or doctorates.

Instrument and response scale

The questionnaire included demographic items and 30 substantive items. Responses to Q1-Q30 were coded on a five-point ordered frequency/agreement scale: 1 = Rarely, 2 = Sometimes, 3 = Moderately, 4 = Often, and 5 = Always. Higher values therefore indicate stronger endorsement or frequency of the specific item wording. Because several implementation-related items were negatively worded, item wording and coding direction were reviewed before scale construction.

The original conceptual domains were pedagogical perceptions (Q1-Q5), meaningful learning and engagement (Q6-Q10), innovative pedagogy (Q11-Q15), future readiness (Q16-Q20), implementation-related perceptions and barriers (Q21-Q26), and strategic support for STEM integration (Q27-Q30). Item screening led to targeted refinements. Q16 was removed from the future-readiness composite because its corrected item-total correlation was very low in the original five-item pool. Q22 was reverse-coded because the original wording was negative: 'Teachers do not always have sufficient training to implement STEM.' The revised tables therefore label Q22 as an insufficient-training item and mark the retained score as Q22R.

Ethical considerations and data handling

Institutional permission and ethics approval for the secondary aggregate analysis of the de-identified programme-linked dataset were granted by ORT Ronson Osafia, institution code and approval identifier 344234. Participation in the programme-linked survey was voluntary. The analytic file was de-identified before analysis, and responses were analyzed only in aggregate form. No names, school identifiers, or personally identifying information were retained in the dataset used for this manuscript. Data were stored securely and were accessible only to the research team. Because the dataset is programme-linked and institutionally sensitive, it is not publicly deposited; access may be considered by the corresponding author subject to ethical, privacy, and institutional restrictions.

Analytic strategy

Analysis proceeded in five stages. First, descriptive statistics were computed for demographic variables and item responses. Second, internal consistency was examined using Cronbach's alpha, corrected item-total correlations, and alpha-if-deleted statistics. Third, gender differences were tested using Welch t tests. Fourth, group differences by age, teaching experience, and academic qualification were examined using Welch ANOVA because Levene tests indicated variance heterogeneity across the group comparisons; Games-Howell post-hoc comparisons were used to locate substantively meaningful differences. Fifth, Pearson correlations and hierarchical ordinary least squares regression were used to examine associations with strategic support for STEM integration.

In the regression analysis, gender, age group, teaching experience, and academic qualification were entered as categorical predictors using dummy coding rather than as continuous linear variables. The order of entry was theoretically and diagnostically motivated: Model 1 entered demographic controls, Model 2 added future readiness, and Model 3 added innovative pedagogy and implementation-related perceptions. This structure allowed the analysis to test whether future-readiness claims remained associated with strategic support once more proximal pedagogical and implementation-related judgments were included. Multicollinearity was assessed using VIF and tolerance statistics. The regression results are interpreted as associations within a single-source, cross-sectional self-report survey, not as causal effects.

RESULTS

The Results section reports the empirical evidence in a sequence that moves from sample description and item-level response patterns to scale refinement, group comparisons, correlations, and regression analyses. Each table is introduced before presentation and then interpreted in the surrounding narrative to maintain a clear connection between statistical output and substantive meaning.

Table 1 introduces the demographic structure of the 589 participating teachers and establishes the sample context for all subsequent analyses.

Table 1

Demographic characteristics of the teacher sample (N = 589)

Variable	Category	n	%
gender	Male	118	20.00
gender	Female	471	80.00
age_grp	Under 30	83	14.10
age_grp	30-40	140	23.80
age_grp	41-50	315	53.50
age_grp	Over 50	51	8.70
teach_exp	Under 5	86	14.60
teach_exp	5-10	164	27.80
teach_exp	Over 10	339	57.60
edu_qual	Diploma	51	8.70
edu_qual	Bachelor	86	14.60
edu_qual	Master	417	70.80
edu_qual	Doctorate	35	5.90

Table 2 presents the descriptive profile of the first ten questionnaire items, covering pedagogical perceptions and early engagement-related indicators.

Table 2

Item-level descriptive statistics for Q1-Q10

Item	Label	Mean	SD	Skew	Kurtosis
Q1	STEM improves teaching quality	3.21	1.10	-0.07	-1.00
Q2	STEM links theory and practice	3.38	1.04	-0.25	-1.34
Q3	STEM matches current educational needs	1.96	1.21	1.06	-0.02
Q4	STEM enhances learning relevance	2.95	1.05	0.12	-1.22
Q5	STEM improves teaching-learning processes	2.77	0.94	0.28	-1.05
Q6	STEM deepens understanding	1.91	0.89	0.65	-0.44

Table 2
Continued

Item	Label	Mean	SD	Skew	Kurtosis
Q7	STEM increases student engagement	3.42	0.93	-0.89	0.18
Q8	STEM supports meaningful active learning	3.04	1.23	-0.06	-0.94
Q9	STEM integrates knowledge fields	3.51	0.90	-1.19	1.04
Q10	STEM increases student motivation	2.83	1.02	-0.41	-0.95

Table 3 extends the item-level profile to the innovation and future-readiness items, highlighting variation in teachers' endorsement of classroom innovation and future-oriented claims.

Table 3
Item-level descriptive statistics for Q11-Q20

Item	Label	Mean	SD	Skew	Kurtosis
Q11	STEM promotes innovative teaching methods	3.24	1.11	-0.43	-0.67
Q12	STEM supports creativity	2.78	1.10	0.20	-1.01
Q13	STEM strengthens complex problem solving	2.89	0.97	0.26	-0.67
Q14	STEM supports collaborative learning	3.34	0.96	-0.11	-1.12
Q15	STEM increases pedagogical flexibility	3.47	0.90	-0.20	-0.79
Q16	STEM develops future work skills	3.06	1.04	0.44	-1.11
Q17	STEM strengthens critical thinking	2.72	1.01	0.24	-0.85
Q18	STEM advances technological literacy	3.18	0.98	0.01	-1.38
Q19	STEM prepares students for future challenges	1.76	0.90	0.98	0.06
Q20	STEM improves decision-making and problem solving	2.51	0.87	0.34	-0.68

Table 4 reports the original wording and descriptive statistics for the implementation-related and strategic support items, including the negatively worded Q22 item before reverse coding.

Table 4
Item-level descriptive statistics for Q21-Q30

Item	Label	Mean	SD	Skew	Kurtosis
Q21	Lack of time limits STEM implementation	2.51	0.93	0.58	-0.43
Q22	Teachers do not always have sufficient training	2.17	0.92	0.44	-0.60
Q23	School resources do not always support STEM	3.21	0.93	-1.07	0.25
Q24	Curricular structures limit full STEM integration	2.95	1.23	0.16	-0.84
Q25	Broader institutional support is required	3.39	0.95	-0.85	-0.01
Q26	I support expanding STEM in my institution	2.48	0.99	0.00	-1.03
Q27	I would recommend STEM as a core component	2.90	1.21	-0.24	-1.19
Q28	STEM can improve student achievement	2.47	1.04	0.97	-0.08
Q29	STEM is central to future-oriented schooling	2.57	0.99	0.70	-0.11
Q30	Overall, STEM integration is positive	2.87	0.93	0.61	-0.82

Note. Q21-Q25 are reported here according to their original wording. Q22 was reverse-coded only for the revised implementation-related perceptions composite.

Measurement refinement and reliability

The revised measurement model treated all scales as exploratory composites. Pedagogical perceptions and strategic support remained stable. Future readiness improved after Q16 was removed, increasing alpha from .70 in the original five-item version to .82 in the revised four-item version. Q19 was retained because, after removing Q16, it showed acceptable item coherence and provided a conceptually central indicator of future challenges. Innovative pedagogy was retained as a three-item non-overlapping composite (Q11, Q13, Q15), while Q12 and Q14 were reassigned to the engagement-and-motivation composite because they captured creativity and collaborative participation rather than general innovation alone. The implementation-related perceptions composite retained Q21, Q22R, Q23, and Q26. It is interpreted as an exploratory composite that combines implementation constraints, perceived training adequacy, resource conditions, and institutional expansion support, not as a validated latent construct or a pure measure of favorable implementation conditions.

Table 5 summarizes the final exploratory composites, retained items, reliability coefficients, and composite means after item screening and coding review.

Table 5

Reliability and descriptive statistics for the revised exploratory composites

Scale	Retained items	Items	Cronbach alpha	Mean	SD
Pedagogical perceptions	Q1, Q2, Q3, Q4, Q5	5	0.90	2.86	0.90
Engagement and motivation	Q7, Q10, Q12, Q14	4	0.82	3.09	0.81
Innovative pedagogy	Q11, Q13, Q15	3	0.85	3.20	0.87
Future readiness	Q17, Q18, Q19, Q20	4	0.82	2.54	0.76
Implementation-related perceptions	Q21, Q22R, Q23, Q26	4	0.75	3.01	0.71
Strategic support for STEM	Q27, Q28, Q29, Q30	4	0.91	2.70	0.92

Note. Q22R denotes reverse coding of the original insufficient-training item. The implementation-related perceptions composite is exploratory and should not be interpreted as a validated latent construct or as a pure favorable-conditions scale.

Table 6 documents the main item-screening decisions so that readers can see which items were removed, reassigned, or reverse-coded and why the final composites should remain exploratory.

Table 6

Item-screening decisions for revised or contested domains

Original domain	Item	Item wording	Decision	Corrected item-total in original pool	Alpha if deleted from original pool	Final assignment
Original meaningful-learning pool	Q6	STEM deepens understanding	Excluded after item coherence screening	-0.33	0.45	Not retained
Original meaningful-learning pool	Q8	STEM supports meaningful active learning	Excluded after item coherence screening	0.23	-0.14	Not retained
Original meaningful-learning pool	Q9	STEM integrates knowledge fields	Excluded after item coherence screening	0.32	-0.15	Not retained
Original innovation pool	Q12	STEM supports creativity	Reassigned and retained	0.84	0.90	Engagement and motivation
Original innovation pool	Q14	STEM supports collaborative learning	Reassigned and retained	0.82	0.90	Engagement and motivation
Original future-readiness pool	Q16	STEM develops future work skills	Excluded after item-total screening	0.05	0.82	Not retained
Original implementation pool	Q22	Teachers do not always have sufficient training	Reverse-coded and retained	-0.45	0.52	Implementation-related perceptions (Q22 reverse-coded)
Original implementation pool	Q24	Curricular structures limit full STEM integration	Excluded after item coherence screening	0.30	-0.09	Not retained
Original implementation pool	Q25	Broader institutional support is required	Excluded after item coherence screening	0.07	0.19	Not retained

Note. The table focuses on items that were removed, reverse-coded, or reassigned during scale refinement. Full diagnostics are available in the statistical output file.

Gender and group differences

Welch t tests showed selective gender differences. Women scored higher on pedagogical perceptions, whereas men scored higher on future readiness and strategic support; however, differences were not broad enough to suggest a general gender divide in STEM orientation. Group analyses showed stronger differences by age, experience, and qualification. Because Levene tests indicated variance heterogeneity in several comparisons, Welch ANOVA and Games-Howell post-hoc logic were used to guide interpretation, with emphasis placed on effect sizes and substantive patterns rather than p-values alone.

Table 7 presents Welch t tests for gender differences across the revised composites, allowing the interpretation to focus on selective rather than generalized gender patterns.

Table 7

Welch t tests comparing men and women across the revised composites

Scale	Men M	Men SD	Women M	Women SD	t	df	p	d
Pedagogical perceptions	2.55	0.65	2.93	0.94	-5.16	254.60	< .001	-0.43
Engagement and motivation	3.11	1.01	3.09	0.75	0.19	151.10	.853	0.02
Innovative pedagogy	3.14	1.19	3.21	0.77	-0.62	142.50	.535	-0.08
Future readiness	2.73	0.66	2.50	0.77	3.34	206.60	< .001	0.31
Impl.-related perceptions	2.89	0.84	3.03	0.68	-1.67	156.50	.097	-0.20
Strategic support for STEM	2.90	1.38	2.65	0.76	1.86	135.50	.065	0.27

Table 8 reports Welch ANOVA results for age-group differences because variance homogeneity was violated across several outcomes.

Table 8

Welch ANOVA by age group

Scale	Welch F	df1	df2	p	EtaSq	Levene p
Pedagogical perceptions	76.61	3	163.80	< .001	0.18	< .001
Engagement and motivation	189.65	3	182.60	< .001	0.37	< .001
Innovative pedagogy	788.09	3	243.40	< .001	0.54	< .001
Future readiness	14.18	3	156.10	< .001	0.06	< .001
Impl.-related perceptions	21.19	3	164.50	< .001	0.11	< .001
Strategic support for STEM	146.91	3	208.40	< .001	0.29	< .001

Note. Levene tests indicated variance heterogeneity; Welch ANOVA and Games-Howell post-hoc comparisons were therefore used for interpretation. The emphasis is on effect sizes and substantively meaningful patterns rather than p-values alone.

Table 9 provides the age-group means that support the interpretation of the Welch ANOVA results and locate the substantive pattern behind the large age-related effects.

Table 9

Group means by age group

age_grp	pedagogical	engagement	innovative	future	impl.-related perceptions	strategic
Under 30	2.09	2.57	2.14	2.74	2.93	2.21
30-40	3.37	3.66	3.62	2.24	2.82	2.41
41-50	2.84	3.17	3.51	2.58	3.20	3.13
Over 50	2.78	1.91	1.84	2.82	2.44	1.65

Table 10 presents Welch ANOVA results by teaching experience, again prioritizing robust interpretation under unequal variance conditions.

Table 10

Welch ANOVA by teaching experience

Scale	Welch F	df1	df2	p	EtaSq	Levene p
Pedagogical perceptions	10.72	2	216.90	< .001	0.03	< .001
Engagement and motivation	4.58	2	231.60	.011	0.01	< .001
Innovative pedagogy	33.66	2	216.60	< .001	0.11	.019
Future readiness	75.93	2	227.90	< .001	0.20	.042
Impl.-related perceptions	55.42	2	226.30	< .001	0.10	< .001
Strategic support for STEM	7.45	2	273.90	< .001	0.02	< .001

Table 11 shows the composite means by teaching experience, clarifying how less experienced, mid-career, and highly experienced teachers differed across the exploratory dimensions.

Table 11

Group means by teaching experience

teach_exp	pedagogical	engagement	innovative	future	impl.-related perceptions	strategic
Under 5	2.49	2.90	2.67	2.75	3.10	2.53
5-10	3.02	3.03	2.99	3.01	3.34	2.55
Over 10	2.87	3.17	3.43	2.26	2.82	2.81

Table 12 reports Welch ANOVA results by academic qualification and indicates where qualification-related differences were most visible.

Table 12

Welch ANOVA by academic qualification

Scale	Welch F	df1	df2	p	EtaSq	Levene p
Pedagogical perceptions	233.41	3	141.40	< .001	0.28	< .001
Engagement and motivation	43.67	3	111.10	< .001	0.15	< .001
Innovative pedagogy	213.59	3	146.30	< .001	0.21	< .001
Future readiness	113.02	3	130.70	< .001	0.09	< .001
Impl.-related perceptions	150.17	3	150.90	< .001	0.11	< .001
Strategic support for STEM	128.17	3	141.00	< .001	0.10	< .001

Table 13 provides qualification-group means, allowing the statistical results to be interpreted as substantive response patterns rather than as p-values alone.

Table 13

Group means by academic qualification

edu_qual	pedagogical	engagement	innovative	future	impl.-related perceptions	strategic
Diploma	2.12	2.65	2.73	2.01	3.03	2.81
Bachelor	1.94	2.47	2.36	2.68	2.59	2.07
Master	3.09	3.28	3.39	2.52	3.03	2.76
Doctorate	3.34	3.04	3.67	3.17	3.69	3.36

Games-Howell post-hoc comparisons indicated that the most pronounced age-related differences were concentrated in engagement, innovative pedagogy, and strategic support, particularly where the 30-40 and 41-50 groups differed from the over-50 group. Experience-related differences were most visible for innovative pedagogy, future readiness, and implementation-related perceptions, while qualification-related patterns generally separated master's and doctoral respondents from diploma- and bachelor-level respondents. Given the programme-linked sample and variance heterogeneity, these findings are reported as descriptive group patterns rather than as generalisable population estimates.

Correlations and hierarchical regression

The strongest bivariate association with strategic support was observed for implementation-related perceptions ($r = .678$), followed by innovative pedagogy ($r = .582$), engagement and motivation ($r = .446$), and future readiness ($r = .405$). The revised future-readiness and implementation-related perceptions composites remained strongly correlated ($r = .748$), indicating conceptual overlap and the possibility of suppression in multivariable regression.

Table 14 presents the correlation matrix among the exploratory composites and shows the overlap that motivated caution in the regression interpretation.

Table 14

Pearson correlations among the revised exploratory composites

Scale	pedagogical	engagement	innovative	future	impl.-related perceptions	strategic
pedagogical	1.00	0.64	0.52	0.31	0.22	0.04
engagement	0.64	1.00	0.77	0.14	0.34	0.45
innovative	0.52	0.77	1.00	0.04	0.21	0.58
future	0.31	0.14	0.04	1.00	0.75	0.41
implementation-related perceptions	0.22	0.34	0.21	0.75	1.00	0.68
strategic	0.04	0.45	0.58	0.41	0.68	1.00

Table 15 summarizes the hierarchical regression models used to examine within-questionnaire associations with strategic support for STEM integration. The table is introduced here because it provides the final inferential synthesis of the Results section. Demographic controls were entered first, future readiness was added second, and innovative pedagogy together with implementation-related perceptions were added in the final model. The regression is interpreted as correlational and cross-sectional, not as evidence of causal effects. Table 15 summarizes the hierarchical regression models predicting strategic support and provides the final inferential synthesis of demographic controls, future readiness, innovative pedagogy, and implementation-related perceptions.

Table 15

Hierarchical regression model summary predicting strategic support for STEM integration

Model	R	R^2	Adj. R^2	Delta R^2	F	p	df_model	df_resid
M1	0.64	0.41	0.40	0.41	44.55	< .001	9	579
M2	0.77	0.60	0.59	0.19	85.13	< .001	10	578
M3	0.89	0.78	0.78	0.19	174.39	< .001	12	576

In the final model, innovative pedagogy (B = 0.56, beta = .53, p < .001) and implementation-related perceptions (B = 1.05, beta = .81, p < .001) were positively associated with strategic support. Future readiness had a negative adjusted coefficient (B = -0.23, beta = -.19, p < .001), which is interpreted as a suppression pattern under overlap with implementation-related perceptions rather than as a substantively negative relationship. Collinearity diagnostics indicated moderate VIF values for future readiness (5.41), innovative pedagogy (3.41), and implementation-related perceptions (4.64); therefore, the results are reported as strong within-questionnaire associations, not as causal explanation.

DISCUSSION

Main empirical pattern

The central empirical pattern is that teachers responded most positively to classroom-proximal dimensions of STEM integration, particularly engagement, innovation, and practical implementation. This supports the view that teachers judge STEM less through abstract reform language and more through its perceived usability in everyday pedagogical work. The finding is consistent with implementation-oriented STEM scholarship emphasising enactment, task design, and professional feasibility (Margot & Kettler, 2019; Stevenson et al., 2026; Thibaut et al., 2019).

Future readiness remained important but psychometrically and statistically more complex. Removing Q16 improved the scale, and the revised composite correlated positively with strategic support at the bivariate level. However, once implementation-related perceptions were entered, its coefficient became negative. Given the strong correlation between future readiness and implementation-related perceptions, this negative coefficient is best interpreted as suppression produced by overlapping predictors, not as evidence that future readiness reduces support for STEM.

Implementation-related perceptions and the meaning of strategic support

Implementation-related perceptions were the strongest within-questionnaire correlate of strategic support. This does not justify a causal claim, because the data are cross-sectional, single-source, and based on self-report composites. It does suggest, more cautiously, that support for STEM was closely associated with teachers' evaluations of time, training, resources, and institutional expansion support within the same programme-linked survey. This interpretation aligns with recent European Journal of STEM Education work emphasizing implementation systems, teacher training, and digital or technology-rich support needs in STEM contexts (Blankendaal-Tran et al., 2026; Morais et al., 2025; Penchev, 2025; Segarra-Morales & Rodríguez-Miranda, 2026).

The implementation-related perceptions composite should also be read cautiously. It is not a pure index of favorable school conditions. Rather, it captures a programme-linked implementation profile in which teachers recognise constraints while also evaluating training adequacy and institutional expansion support. Q26 was therefore retained as an indicator of institutional expansion support within the implementation context, not as a broad strategic-support item. This nuance is important because reform support may coexist with awareness of constraints; teachers may support STEM precisely because they recognise the conditions that must be improved for it to succeed.

Israeli and comparative relevance

The Israeli context gives the study practical relevance, but the empirical claims must remain bounded. The dataset does not include school sector, region, subject, school level, socioeconomic context, or years of programme involvement. Therefore, the findings cannot test sectoral inequalities directly. They instead point to questions that future Israeli STEM research should examine more systematically, especially given documented variation in teacher supply, teacher preparation, and STEM opportunity across contexts (Bisan Ali et al., 2025; Donitsa-Schmidt, 2025; Guberman, 2025).

Comparatively, the study adds to a growing body of evidence showing that teacher support for STEM depends on implementation credibility. Technological education appears especially suited to integrated STEM when it connects disciplinary knowledge to design-oriented, material, collaborative, and problem-based learning. Yet this potential depends on professional learning, assessment clarity, and organizational structures that make integration sustainable rather than episodic.

CONCLUSION

This study provides a programme-linked exploratory account of teacher perceptions of STEM integration in technological education in Israel. The findings indicate that teachers' strategic support for STEM is associated most strongly with implementation-related perceptions and innovative pedagogy within the questionnaire dataset. These associations should not be read causally or as population-level evidence. Rather, they show that teachers in this programme-linked field survey appeared more persuaded by STEM when it was connected to usable classroom practices, visible student engagement, and credible organizational conditions than when it was framed only through broad future-oriented policy language.

The study also demonstrates the importance of transparent measurement reporting in field-based STEM research. Several initial item clusters required refinement, Q16 weakened future-readiness reliability, and Q22 required reverse coding according to its original negative wording. Treating the resulting dimensions as exploratory composites, rather than as validated latent constructs, strengthens the credibility of the analysis and prevents overgeneralisation.

For policy and practice, the findings support a bounded implication: in this programme-linked sample, teachers' strategic support for STEM was associated with practical implementation-related perceptions and innovative pedagogy. Therefore, STEM initiatives should give attention to design-based professional learning, protected planning time, accessible resources, assessment tools, and school-level routines that help teachers translate integration into sustained pedagogy. Broader policy claims require representative and longitudinal evidence beyond the present dataset.

Limitations and Future Research

Several limitations should be acknowledged. First, the study used a non-probability, programme-linked sample and therefore cannot be generalized to all teachers in Israel. Second, the dataset did not include school sector, region, school level, teaching subject, socioeconomic context, response rate, number of invited teachers, or years of programme involvement. Third, the data were collected over a short period and relied entirely on teacher self-report. Fourth, the psychometric structure was exploratory, with some initial domains showing weak coherence and requiring refinement. Fifth, the high regression R-squared should be interpreted cautiously because the predictors and outcome were measured in the same questionnaire and may reflect common method variance and overlapping item content rather than broad causal explanatory power.

Future research should validate the revised scale structure in independent samples using confirmatory factor analysis and multi-group measurement testing. It should also collect sectoral and school-context variables, combine survey responses with classroom observation or interview data, and examine whether improved implementation-related perceptions are associated with durable changes in STEM teaching practice and student learning. Longitudinal designs would be especially useful for clarifying how teacher support develops over time as STEM reforms move from programme-linked activity to institutional routine.

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Ethical statement

Institutional permission and ethics approval for the secondary aggregate analysis of the de-identified programme-linked dataset were granted by ORT Ronson Osafia, institution code and approval identifier 344234. Participation in the programme-linked survey was voluntary. The analytic file was de-identified before analysis, and responses were analyzed only in aggregate form. No names, school identifiers, or personally identifying information were retained in the dataset used for this manuscript. Data were stored securely and were accessible only to the research team.

Competing interests

No potential conflict of interest was reported by the authors.

Author contributions

Conceptualization, N.T. and S.A.R.; methodology, N.T. and S.A.R.; formal analysis, N.T.; investigation, N.T. and S.A.R.; data curation, N.T.; writing - original draft preparation, N.T. and S.A.R.; writing - review and editing, N.T. and S.A.R.; supervision, N.T. and S.A.R.; project administration, N.T. All authors have read and agreed to the published version of the manuscript.

Data availability

The de-identified data analyzed in this study are available from the corresponding author on reasonable request, subject to ethical, privacy, and institutional restrictions, including the institutional permission conditions governing the programme-linked dataset.

AI disclosure

The authors acknowledge the use of ChatGPT by OpenAI for language editing, structural refinement, and clarity checking during the revision process. The authors independently reviewed, verified, and approved all analyses, interpretations, references, and final content. No generative AI tool was used to create, alter, or manipulate images, figures, or research data.

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