The Future of Engineering Education
2024 Annual Conference & Exposition
Oregon Convention Center
Portland, OR . June 23 - 26, 2024
ASEE
Paper ID #43215

Unveiling the Impact of Teachers' Beliefs on Student Development in Rural STEM Education: Roles of Classroom Evaluation, STEM Literacy and Subject Type

Yi Wang
Fangyuan Chai
Yuan Liu
Jun Zhu
Jing Jin

Unveiling the Impact of Teachers' Beliefs on Student Development in Rural STEM Education: Roles of Classroom Evaluation Practice, STEM Literacy and Course Subject

Yi Wang[1], Fangyuan Chai[1]*, Yuan Liu[1], Jun Zhu[1], Jing Jin[1]

1 Graduate School of Education, Beijing Foreign Studies University, Beijing 10080, China.

*Correspondence: No 19 Xisanhuan North Road, Haidian District, Beijing, China; Chaify@bfsu.edu.cn

Abstract: The provision of high-caliber STEM education in rural areas is pivotal for the enduring progression and self-sufficiency of these communities. Within this educational framework, classroom evaluation practice is instrumental in cultivating student achievement and personal growth. This empirical study investigates how rural Chinese teachers' STEM literacy shapes their approach to assessing student performance, thereby impacting the effectiveness of pedagogical strategies. Utilizing self-reported data from online surveys, this study uncovers a robust positive linkage between the educators' beliefs pertaining to STEM and their evaluative techniques within the classroom setting. Specifically, instructors with strong convictions regarding STEM are more inclined to implement a variety of assessment methods, coupled with constructive evaluation principles, to bolster student learning outcomes. Furthermore, the study reveals that the STEM literacy of rural teachers serves as an intermediary between their teaching beliefs and evaluation approaches. In addition, the academic course subject instructed by these educators acts as a moderator in the relationship, underscoring the integration of humanities with STEM disciplines to achieve a balanced and comprehensive education. Highlighting the urgency of refining assessment practices and enhancing STEM literacy among rural educators, this study calls for future scholarly inquiries into the incorporation of liberal arts with STEM pedagogy. Such initiatives aim to elevate interdisciplinary teaching standards, tackle the unique challenges faced by rural regions, and promote the all-encompassing advancement of students in these areas, thereby propelling the progression of STEM education at large.

Keywords: STEM education; Rural teachers; Teaching beliefs; Classroom evaluation practice; STEM literacy; Course subject

1. Introduction

The development of modern society is closely tied to the progress and innovation in science and technology [1]. Rural STEM education becomes instrumental in driving

high-quality educational development in rural areas. It's imperative to concentrate on cultivating high-level innovative professionals and improving educational quality, a process that hinges heavily on skilled teachers. Teachers significantly influence student outcomes, particularly in impoverished, remote, or transient communities [2, 3]. The nuanced "self-internal landscape of teaching" now receives greater attention, acknowledging that a teacher's belief system underpins their educational methodologies and is integral to achieving successful learning outcomes [4]. However, the acceleration of STEM education reform has heightened the demand for teacher proficiency. Research consistently points to a scarcity of specialized teachers as an impediment to STEM educational reforms, with a lack of teacher competency posing a formidable challenge to its implementation [5]. Despite the incorporation of interdisciplinary practices in all subjects following the 2022 curriculum reforms, many subject teachers find themselves ill-equipped to deliver this comprehensive content effectively [6]. Rural schools, in particular, face an uphill battle in implementing STEM education [7].

To overcome the prevailing challenges of STEM education, it is essential to construct and fortify a robust classroom evaluation framework, encompassing comprehensive metrics, varied evaluative methods, and the strategic application of findings to synchronize improvements in both teaching and student learning trajectories.

Therefore, this study aims to deepen our understanding of the application of STEM education in rural schools, enhance teachers' STEM literacy through practical experiences, improve the content and format of classroom evaluation practices, and promote high-quality learning and development among students. It intends to address the following research questions within the context of rural education under the backdrop of digital intelligence: How do rural teachers' teaching beliefs impact their classroom evaluation practice during STEM education implementation?

2. Literature Review

2.1 Teaching Belief and Classroom Evaluation Practice

The term "teaching belief" encapsulates the constellation of a teacher's enduring perceptions regarding their role in education, the nature of the curriculum, and the mechanisms through which students assimilate knowledge. These beliefs are not mere abstractions but are forged from the amalgam of a teacher's empirical encounters and existential reflections, thereby guiding their educational philosophy and praxis [8, 9, 10]. Within the scope of this study, "teaching belief" is understood as the ingrained convictions held by educators about their pedagogical duties, student engagements, curricular substance, and the comprehensive process of instruction, which ultimately direct their didactic ideologies and methodologies.

The efficacy of classroom evaluation practice is well-documented, with substantial evidence highlighting its pivotal role in enhancing student achievement and fostering an intrinsic motivation to pursue academic objectives [11, 12]. This analysis delineates evaluation not only as a multifaceted political dynamic within the classroom environment but also as a catalyst for teacher evolution and professional growth [13].

Herein, classroom evaluation practice is characterized by the distinctive approach teachers adopt to gauge student learning outcomes. This involves a consideration of whether educators incorporate a variety of assessment modalities in their pedagogy.

A nuanced interplay exists between a teacher's teaching beliefs and the manner in which they conduct classroom evaluations. Such beliefs insidiously inform their appraisal techniques; specifically, the nature of these beliefs dictates the selection of assessment strategies [14]. Moreover, it is posited that an educator's doctrinal underpinnings precipitate behaviors that influence curriculum evaluation, thereby impacting the determination of objectives, content, pedagogical approaches, and evaluative tools [15]. This suggests a scenario wherein rural educators with a strong ideological commitment to STEM education are more likely to deploy a spectrum of robust evaluation methods that reinforce student success and growth.

Building upon this reasoning, the study introduces Hypothesis 1: The teaching beliefs of rural teachers pertaining to STEM education exert a positive impact on their classroom evaluation practice, implying that resolute pedagogical convictions correlate with the utilization of varied and effective evaluation techniques.

2.2 STEM Literacy and Classroom Evaluation Practice

This paper adopts a comprehensive view of STEM literacy, recognizing it as both an understanding of the integrated aims of its constituent disciplines and the application of this integrated thinking to real-world problems, in sync with current essential competencies. Consistently, it shows that STEM literacy has important implications for classroom assessment [16]. Their work in developing evaluative standards revealed that teachers with high competency in STEM demonstrated superior pedagogic skills, highlighting the link between STEM literacy and teaching efficacy.

Classroom evaluation practice is fundamentally intertwined with pedagogical practice. It is incumbent upon teachers to craft and foster learning environments conducive to holistic student development. These environments should nurture independence, creativity, and advancement—all attributes that are encompassed by STEM literacy, particularly in terms of course development and fine-tuning [17]. Teachers' adept in STEM are consequently more capable of adapting instruction to meet student needs, leading to more favorable assessment results.

With these considerations in mind, the study introduces Hypothesis 2: Rural teachers' STEM literacy acts as a link between their teaching beliefs about STEM and their classroom evaluation practice. More concretely, rural teachers with firm convictions about the value of STEM education are likely to have higher levels of STEM literacy, thereby enhancing their evaluative strategies in the classroom.

2.3 The Course Subject and STEM Education

Within the framework of STEM education, numerous micro-level studies have focused on developing specific STEM-related skills. For instance, there's a course titled "Catch the Wind: Design a Windmill," aiming to equip students with the ability to harness wind energy through engineering design. It leverages physics knowledge about wind energy, material properties, windmill construction, and angular concepts to enable

students to create devices powered by wind. This course targets not only competency but also the cultivation of scientific values [18]. STEM literacy is distinguished from singular STEM literacy, because it highlights the skills and practices that are unique to each particular discipline, and therefore not applicable in all the other disciplines [19]. Often facilitated by digital teaching methods, these approaches subtly enhance scientific literacy and problem-solving abilities. While debate centered on the role of discipline knowledge, which influenced both the "entry point" and design of STEM curriculum, and to a lesser extent, pedagogical approaches that support STEM skills, dispositions and capabilities [20]. Correspondingly, there is substantial research into STEM education within fields like physics, mathematics, chemistry, and general sciences, but exploration into liberal arts subjects, such as language curricula, is limited.

Therefore, this study posits Hypothesis 3: The impact of rural teachers' teaching beliefs on classroom evaluation practices is moderated by the course subject they teach, with engineering teachers experiencing a more pronounced effect of their beliefs on evaluation compared to those teaching liberal arts.

Therefore, a hypothetical model of the role of STEM literacy and course subject in the relationship between rural teachers' teaching beliefs in STEM education and their classroom evaluation practice is proposed in this study (see Figure 1).

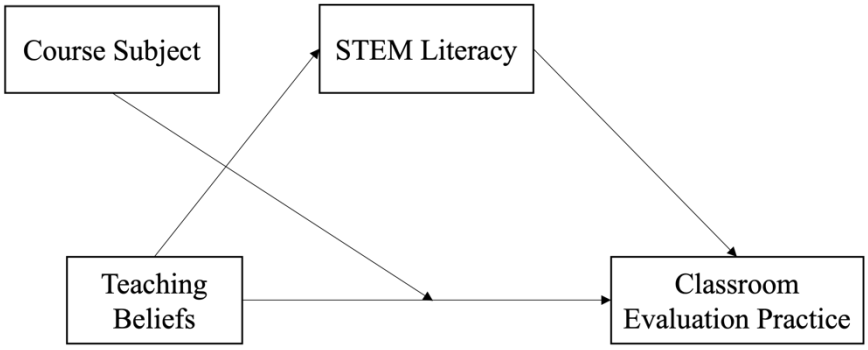

Figure 1 Hypothetical model of the role of STEM literacy and course subject in the relationship between rural teachers' teaching beliefs in STEM education and their classroom evaluation practice.

3. Study 1: The Impact of Rural Teachers' Teaching Beliefs on Their Classroom Evaluation Practice

Study 1 aims to investigate the influence of rural teachers' teaching beliefs on the selection of their classroom evaluation activities within the context of STEM education.

3.1 Methods

3.1.1 Participants

The participants were randomly recruited on the online data collection platform Credamo, and 8 were excluded for completing the questionnaire in too short a time or not meeting the response requirements. All participants must be current Chinese rural teachers in junior high schools. The final sample included 202 participants (M_{age} = 30.33, SD_{age} = 9.48), of which 56 were male and 146 were female. Within the sample,

43.6% of the rural teachers were categorized as liberal arts teachers, while the remaining 56.4% were categorized as engineering teachers.

3.1.2 Variables Selection and Measurement Tools

Independent Variable (Teaching Beliefs) The Teaching Beliefs Scale in STEM education (Cronbach's α = 0.80) developed by the National Institute of Education Sciences of China [21] was utilized as the measurement tool, revised according to the experimental scenario, retaining 11 items, including 2 reverse-scored items. Representative items include "I believe I can effectively teach my content," "I doubt whether I have the necessary skills to teach STEM content," etc. The scale was scored on a 7-point scale from 1 to 7, ranging from "strongly disagree" to "strongly agree."

Dependent Variable (Classroom Evaluation Practice) The RTOP Classroom Observation Protocol (Cronbach's α = 0.73) commonly used to measure the effectiveness of K-12 STEM teaching was selected as the measurement tool, revised according to the experimental scenario, retaining 6 items related to classroom learning valuation [22]. Representative items include "There are diverse evaluators in the classroom evaluation," "I use process-oriented evaluation in the classroom," etc. The scale was scored on a 7-point scale from 1 to 7.

Control variable (Gender and Education Background) Existing research has shown that in the field of STEM education, teachers of different genders employed varied methods of teacher-student interaction and teaching approaches during the instructional process, which would further impact students' learning motivation, expectations, and development [23, 24, 25, 26]. Furthermore, teachers with different education backgrounds demonstrated differing cognitive and applied abilities in STEM education, further affecting their classroom teaching behaviors [27, 28]. Considering that the gender and education background of rural teachers may influence the classroom evaluation practice examined in this study, they were included as control variables.

3.2 Results

Taking rural teachers' teaching beliefs as the independent variable and their classroom evaluation practice as the dependent variable, the linear regression analysis was conducted on the sample. The results (see Table 1) indicated that the Durbin-Watson statistic was 1.96, indicating minimal autocorrelation among the observations, while the variance inflation factor (VIF) was well below 10, suggesting no severe multicollinearity issues among the variables. The regression model was highly significant (p<0.001), with rural teachers' teaching beliefs in STEM education accounting for 31.5% of the variance in their classroom evaluation practices. In other words, rural teachers' teaching beliefs (M=5.41, SD=0.66) significantly positively influenced their classroom evaluation practice (M=5.86, SD=0.64) (β=0.57, p<0.001). On average, rural teachers reported positive attitudes towards STEM education and were likely to practice effective classroom evaluations. This suggested that as rural teachers' beliefs in the value and effectiveness of STEM education increased, so did their engagement with diverse and positive assessment strategies in the classroom.

Table 1 Standardized Regression Coefficients in Study 1

Dependent Variable	Independent Variable	R^2	F	β	95%CI
Classroom Evaluation Practice	Teaching Beliefs	0.315	93.54***	0.57***	[0.44, 0.66]

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Therefore, Study 1 confirmed the influence of rural teachers' teaching beliefs on their classroom evaluation practice, indicating that in the context of STEM education, rural teachers with stronger teaching beliefs were more inclined to adopt diverse valuation methods and positive valuation principles in the classroom to promote students' learning and development.

4. Study 2: The Mediating Role of Rural Teachers' STEM Literacy in the Influence of Teaching Beliefs on Classroom Evaluation Practice

Building upon the conclusions of Study 1, Study 2 aims to further examine the mediating role of rural teachers' STEM literacy levels. That is to say, Study 2 investigated the main effects of teaching beliefs on classroom evaluation practice and how STEM literacy transmits the effect between teaching beliefs and the classroom evaluation practice, i.e., how teaching beliefs affect the classroom evaluation practice through STEM literacy levels.

4.1 Methods

4.1.1 Participants

The participants were randomly recruited on the online data collection platform Credamo, and 14 were excluded for completing the questionnaire in too short a time or not meeting the response requirements. All participants must be current Chinese rural teachers in junior high schools. The final sample included 191 participants (M_{age} = 30.70, SD_{age} = 9.37), of which 54 were male and 137 were female. Within the sample, 45.2% of the rural teachers were categorized as liberal arts teachers, while the remaining 54.8% were categorized as engineering teachers.

4.1.2 Variables Selection and Measurement Tools

The teaching beliefs scale (Cronbach's α = 0.80) and classroom evaluation scale (Cronbach's α = 0.73) remained consistent with Study 1. The control variables in this study, namely gender and educational background, also remained consistent with those in Study 1. Additionally, the measurement of rural teachers' STEM literacy levels was introduced.

Mediating Variable (STEM Literacy) The STEM Literacy Scale (Cronbach's α = 0.92) developed by Chamrat et al. [29] was utilized, consisting of 30 items across 5 dimensions. Representative items include "I understand the integrative concepts of science, technology, engineering, and mathematics that are relevant to life and work," "I agree that the ways of thinking and practices of STEM must be connected with the skills of the 21st century (learning, innovation, media and technology, life and work

skills)," "I can apply concepts and practices of STEM to seek knowledge," etc. The scale was scored on a 7-point scale from 1 to 7.

4.2 Results

4.2.1 Descriptive Statistics and Correlation Analysis

The correlation analysis of the main variables of Study 2 was performed and the results are shown in Table 2. The results showed significant positive correlations between rural teachers' teaching beliefs in STEM education and STEM literacy levels (r=0.67, p<0.01) as well as classroom evaluation (r=0.56, p<0.01); there was also a significant positive correlation between teachers' STEM literacy levels and classroom evaluation (r=0.61, p<0.01). Teachers who hold stronger beliefs in the value and importance of STEM education tended to have higher levels of STEM literacy. Besides, teachers with stronger beliefs regarding the significance of STEM education were more likely to implement diverse and constructive evaluation methods in the classroom.

Table 2 Descriptive Statistics of Variables and Correlation Coefficient Matrix in Study 2

	M±SD	1	2	3
Teaching Beliefs	5.39±0.67			
STEM Literacy	5.44±0.61	0.67**		
Classroom Evaluation	5.84±0.65	0.56**	0.61**	

* p<0.05; ** p<0.01; *** p<0.001

4.2.2 Mediating Effect Test

This study used PROCESS developed by Preacher and Hayes to test the mediating effect of rural teachers' STEM literacy [30]. With teaching beliefs as the independent variable, rural teachers' STEM literacy as the mediating variable, and classroom valuation practice as the dependent variable, Model 4 from the PROCESS program developed by Hayes was selected to test the general mediating effect, as shown in Table 3.

Table 3 Mediating Effect Test of Rural Teachers' STEM Literacy

Equation	Dependent Variable	Independent Variable	R^2	F	β	SE	95%CI
1	Classroom Evaluation Practice	Teaching Beliefs	0.31	85.63***	0.54***	0.06	[0.43, 0.66]
2	STEM Literacy	Teaching Beliefs	0.45	152.87***	0.61***	0.05	[0.51, 0.70]
3	Classroom Evaluation Practice	STEM Literacy	0.41	65.55***	0.45***	0.08	[0.29, 0.61]
		Teaching Beliefs			0.30***	0.07	[0.12, 0.41]

* p<0.05; ** p<0.01; *** p<0.001

It can be observed that rural teachers' teaching beliefs significantly predicted their classroom evaluation practice (β=0.54, SE=0.06, p<0.001). Moreover, rural teachers'

teaching beliefs significantly predicted their STEM literacy levels (β=0.61, SE=0.06, p<0.001). When rural teachers' teaching beliefs and STEM literacy levels were simultaneously entered into the regression equation, teaching beliefs still significantly predicted STEM literacy levels (β=0.30, SE=0.07, p<0.001), and STEM literacy levels also significantly predicted classroom evaluation practice (β=0.45, SE=0.08, p<0.001). Therefore, the bias-corrected and accelerated bootstrap indicated that rural teachers' STEM literacy levels played a partial mediating effect between their teaching beliefs and classroom evaluation practice, with the mediating effect accounting for 50.69% of the total effect (See Figure 2).

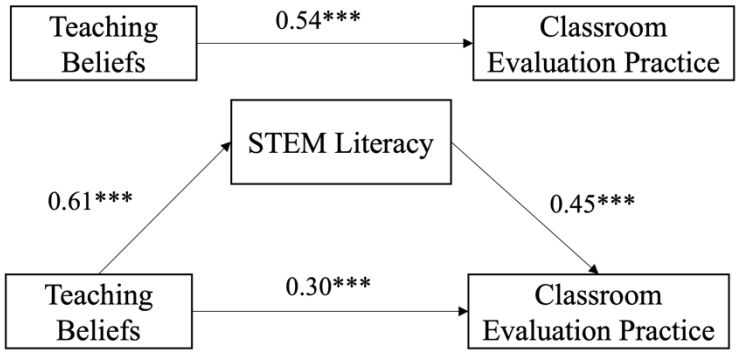

Figure 2 Mediating Effect Model of STEM Literacy

Consequently, Study 2 confirms that rural teachers' STEM literacy partially mediates the link between their teaching beliefs and classroom assessment strategies. This suggests that when rural teachers hold strong beliefs in the value of STEM education, they tend to have higher levels of STEM literacy. This, in turn, impacts their assessment choices, leading them to favor a variety of evaluation techniques and constructive assessment principles, which aim to enhance student learning and growth.

5. Study 3: The Moderating Effect of Course Subject on the Relationship between Teaching Beliefs and Classroom Evaluation Practice among Rural Teachers

Study 3 aims to investigate the nuanced impact that the academic discipline instructed by rural educators imparts on the dynamics between their pedagogical convictions and the assessments of their classrooms. This encompasses an assessment of the manner in which variations in the course subject adjust the correlation intensity or trajectory between the classroom evaluation practice and teaching beliefs at its different strata. That is, the investigation is not limited to the foundational influence exerted by teaching beliefs on classroom evaluations; it also probes into how the subject matter being instructed can pivotally reshape this interconnection.

5.1 Methods

5.1.1 Participants

The participants were randomly recruited on the online platform Credamo, and 4 were excluded for completing the questionnaire in too short a time or not meeting the response requirements. All participants must be current Chinese rural teachers in junior high schools. The final sample included 196 participants (M_{age} = 30.27, SD_{age} = 9.40),

of which 55 were male and 141 were female. Within the sample, 42.9% of the rural teachers were categorized as liberal arts teachers, while the remaining 57.1% were categorized as engineering teachers.

5.1.2 Variables Selection and Measurement Tools

The teaching beliefs scale (Cronbach's α = 0.80) and classroom evaluation scale (Cronbach's α = 0.74) remained consistent with Study 1. The control variables in this study, namely gender and educational background, also remained consistent with those in Study 1.

Moderating Variable (Course Subject) The course subject variable was introduced with the question "What subject type do you teach?" in this study. And the liberal arts were coded as 1 while sciences were coded as 2.

5.2 Results

5.2.1 Descriptive Statistics and Correlation Analysis

Descriptive statistics of the main variables in Study 3 and correlation analysis are presented in Table 4. The results showed a significant positive correlation between rural teachers' teaching beliefs in STEM education and their classroom evaluation (r=0.57, p<0.01). However, the correlation between course subject type and classroom evaluation was not significant (r=0.03, p>0.05).

Table 4 Descriptive Statistics of Variables and Correlation Coefficient Matrix in Study 3

	M±SD	1	2	3
Teaching Beliefs	5.42±0.66			
Course Subject	1.57±0.50	0.05		
Classroom Evaluation Practice	5.86±0.65	0.57**	-0.03	

* p<0.05; ** p<0.01; *** p<0.001

5.2.2 Test for Moderating Effect

With teaching beliefs as the independent variable, classroom evaluation practice as the dependent variable, and the course subject as the moderator variable, Model 1 in the PROCESS program was adopted to test for moderating effects after all continuous variables were centralized. To provide a more intuitive reflection of the moderating effect on rural teachers' teaching beliefs, this study employed a simple slope test [31] so that the teaching beliefs were divided into two groups, weak teaching beliefs and strong teaching beliefs, based on whether they fell within positive or negative one standard deviation.

The results showed that the interaction between teaching beliefs and course subject significantly positively influenced the classroom evaluation (β=0.31, SE=0.11, p<0.01), as illustrated in Figure 3. Specifically, when the subjects rural teachers taught was liberal arts, the teachers' teaching beliefs significantly positively influenced classroom evaluation practice(β=0.38, SE=0.09, t(196)=4.45, p<0.001); when teaching sciences subjects, the influence of teaching beliefs on classroom assessment was further strengthened, indicating that for rural teachers teaching sciences subjects, the impact of

their teaching beliefs on classroom evaluation was more significant (β=0.69, SE=0.08, t(196)=9.11, p<0.001).

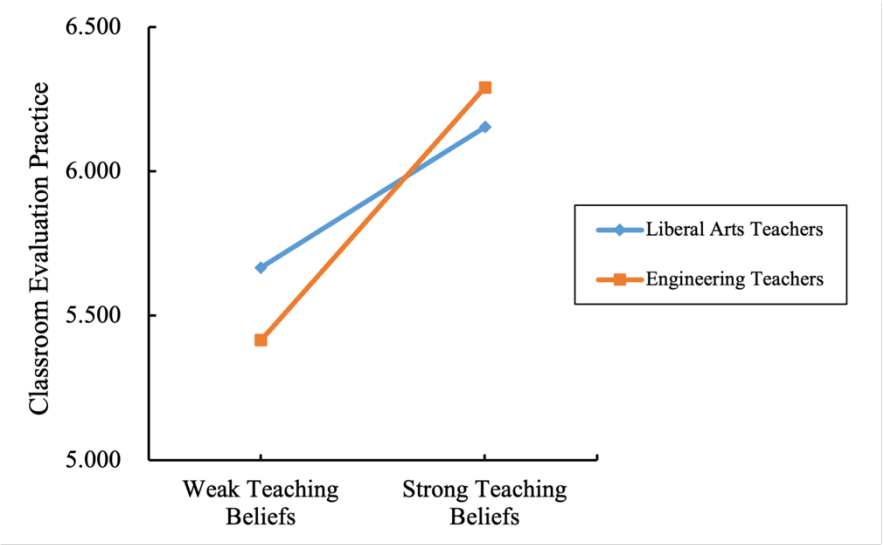

Figure 3 Moderating Effect Model of the Type of Subject

Study 3's findings indicate that the influence of rural teachers' teaching beliefs on their classroom evaluations within a STEM education context is dependent on the subjects they teach, with this dependency serving as a positive moderating factor. Particularly, science subject teachers in rural areas observed a more substantial effect of their teaching beliefs on classroom evaluations. Moreover, liberal arts teachers with less stringent adherence to STEM teaching beliefs tended to utilize a wider array of evaluation techniques and maintain an affirmative approach to assessments. This strategy was aimed at equipping students to meet the demands of the modern era and employed the "promoting learning through evaluation" concept effectively. Conversely, for those who were more firmly rooted in STEM education beliefs, the expression of these beliefs in classroom assessments became more pronounced among science teachers, while it was muted among liberal arts educators.

6. Discussion

On a practical level, this study illuminates current impediments to the high-quality advancement of rural STEM education. For instance, Study 1 underscores the profound impact that rural teachers' beliefs about teaching have on their evaluative practices within the classroom, highlighting a deficiency in these beliefs about STEM education among rural educators. This situation adversely affects the nurturing of students' innovative and practical skills, impeding rural education's high-quality progression [32], [33].

The findings indicate that rural teachers, as vital agents in revitalizing rural education, directly influence resource allocation and the elevation of educational standards through their pedagogical convictions [34].

Additionally, the classroom serves as a pivotal medium for realizing educational value and fostering well-rounded individuals [35]. Thus, rural schools and educators

ought to enhance the construction of a multi-dimensional, diversified, and multi-agent evaluation system [36]. Such enhancements should seamlessly integrate educational technology and innovative pedagogical methodologies to align assessments more closely with students' learning processes and outcomes. Significantly, students' scientific temperament, creativity, and collaboration during the learning process should become key indicators for assessing interdisciplinary thinking capabilities, pinpointing student potential and areas for improvement, and guiding holistic student development through evaluations [37], [38].

On a theoretical plane, this study delineates the logical trajectory for augmenting rural teachers' STEM literacy beginning at the individual micro-level. It establishes that STEM literacy plays a mediating role between teachers' pedagogical beliefs and classroom evaluation methods. Stronger STEM-related teaching beliefs correlate with heightened STEM literacy, consequently refining decisions regarding classroom assessment content and approach.

Furthermore, the study suggests that subject matter influences the interplay between rural teachers' pedagogical beliefs and their evaluation practices within a STEM education paradigm. Specifically, liberal arts teachers with feeble STEM beliefs might conduct higher quality evaluations, employing diverse methods and positive assessment philosophies that better align with modern developmental needs.

This insight uncovers a research bias favoring science-centric disciplines within STEM education, neglecting the vital contribution of liberal arts education. However, there are multiple, equally valid discipline "entry points" to STEM education [39]. Both the science-centric and liberal arts disciplines are equally critical for fostering comprehensive talents capable of multidisciplinary synthesis and innovation [40]. STEM education, therefore, should not exclusively address scientific subjects but rather strive to cultivate innovative and practical capabilities through cross-disciplinary integration, equipping students to solve real-world problems [41], [42].

In pursuit of this goal, humanities subjects like language and history are integral, enhancing metacognition and other 21st-century competencies [43]. Moreover, a humanistic emphasis within STEM curricula is paramount, as neglect here can erode student motivation and engagement [44].

7. Conclusion

In this study, we endeavored to examine the impact of rural teachers' beliefs regarding STEM education on student growth. The evidence gathered demonstrates a noteworthy positive relationship between the educational convictions of rural teachers in the realm of STEM and their practices relating to classroom assessments. Additionally, the study shed light on the role of rural teachers' STEM proficiency as a mediator between their pedagogical beliefs and assessment methods. Despite these findings, the scope of this investigation does include limitations, particularly concerning the general approach to classroom evaluation practices. While the study posed questions about the adoption of varied evaluative tools by rural teachers based

on their STEM beliefs and literacy, it did not deeply investigate how these diverse evaluation tools could enhance the quality of assessments and facilitate student progress.

Future study should broaden the spectrum of STEM education to integrate the perspectives of liberal arts educators and their instructional frameworks. It is essential to recognize that liberal arts and STEM education are not diametrically opposed; rather, they each offer unique benefits that when combined, provide a holistic approach to education. The liberal arts nurture humanistic perspectives, critical thinking, and introspection, whereas STEM instills scientific acumen, logical reasoning, and problem-solving skills. Together, these disciplines support well-rounded student development as referenced in sources [45, 46].

We also discerned that STEM literacy transcends traditional STEM subject areas, indicating an intersection with the liberal arts where development of certain STEM-related skills is necessary. Therefore, future investigations should concentrate more intently on rural education and strategies for implementing high-quality, resource-efficient interdisciplinary STEM instruction. Such efforts are pivotal for supporting the holistic development of students in rural environments. This pursuit extends beyond the principle of educational equity and is instrumental in driving the social progression of rural communities.

References

[1] J. Zhai, J. Zhang and T. Yuan, "Bridging the Gender Gap in STEM: UNESCO's Practices in Promoting Female Participation in STEM Education and Its Reflections", *International and Comparative Education,* vol. 45, no. 4, pp.22-33, 2023.

[2] F. Meng, "The Path of Reform and Development for Normal Universities in the New Era", *Educational Research,* vol.42, no.2, pp.17-21, 2021.

[3] Ministry of Education of the people's Republic of China, "Compulsory Ed ucation Curriculum Framework (2022 Edition)" Available: https://www.ictr.e du.cn/download_center/ywjy.html.

[4] X. Guo, "The Current Situation, Significance and Trend of Research on Teachers' Belief of Teaching", *Studies in Foreign Education,* vol,35, no.10, pp. 92-96, 2008.

[5] H. Zhang, Y. Sheng and C. Nian, "The Resistances of STEAM Educational Reform in China and its Elimination", *Education Sciences in China (In Chinese and English),* vol.*4, no.*2, pp.74-83, 2021.

[6] Y. Zhou, F. Zhang, H. Feng and C. He, "Suggestions for the Construction and Implementation of a Basic Education STEM Teacher Competency Assessment System", *Education & Equipment Research,* vol.9, no.12, pp.15-22, 2023.

[7] J. Si and L. Zhang, "STEM education in rural areas: possibility, dilemma and solution", *Chinese Journal of Distance Education,* vol.42, no.8, pp. 53-59+69+79,2022.

[8] D. M. Kagan, "Implication of research on teacher belief", *Educational psychologist*, vol.27, no.1, pp.65-90,1992.

[9] G. Lyu, “Teachers’ Belief and Its Influencing Factors”, Unpublished doctor al dissertation, Northwest Normal University. Available: https://kns.cnki.net/ kcms2/article/abstract?v=-0THPtffOh0eiJqPNGi-t3YEenL74Mr3zNndveggvqHl 23J7cfvfOHN4RU0JIgYK5rpkvGD8v1fpzO0hFUTwr4mBJ_tnNLcDcn4lBVtW 40XHlEtWWAJxEFMWwHTDoYUq&uniplatform=NZKPT&language=CHS.
[10] M. F. Pajares, “Teachers’ beliefs and educational research: Cleaning up a messy construct”. *Review of educational research*, vol. *62*, no. 3, pp.307-332, 1992.
[11] T. A. Angelo, and K. P. Cross, *Classroom assessment techniques,* Jossey Bass Wiley, 2012.
[12] T. J. Crooks, “The impact of classroom evaluation practices on students”, *Review of educational research*, vol.*58, no.*4, pp.438-481, 1988.
[13] R. Kiely, “Classroom evaluation-values, interests and teacher development”, *Language teaching research*, vol.*5, no.*3, pp.241-261, 2001.
[14] M. Z. Hashweh, “Effects of science teachers’ epistemological beliefs in teaching”, Journal of Research in Science Teaching: The Official Journal of the National Association for Research in Science Teaching, vol.33, no.1, pp.47-63,1996.
[15] N. Rashidi and M. Moghadam, “The discrepancy between teachers’belief and practice, from the sociocultural perspective”, *Studies in English Language Teaching,* vol.3, no.3, pp.252-274, 2015.
[16] S. Guang, “An empirical study on the evaluation of STEM classroom teaching in primary and secondary schools based on high-order thinking Teaching”, *Management and Education Research,* vol.5, no.17, pp.10-14, 2020.
[17] Z. Hao, “Reflection and construction of classroom teaching evaluation in primary and secondary schools”, *Educational Research*, vol.36, no.2, pp.110-116, 2015.
[18] K. Yang, L. Dou and P. Gong, “On professionalism of STEM teachers”, *e-Education Research,* vol.42, no.4, pp.115-121, 2021.
[19] K. S. Tang and P.J. Williams, “STEM literacy or literacies? Examining the empirical basis of these constructs”, *Review of Education*, vol.7, no.3, pp.675-697, 2019.
[20] G. Falloon, M. Hatzigianni, M. Bower, A. Forbes and M. Stevenson, “Understanding K-12 STEM education: A framework for developing STEM literacy”, *Journal of Science Education and Technology*, vol.29, no.3, pp.369-385,2020.
[21] National Institute of Education Sciences of China. “Standards for STEM T eacher Competency Levels (Trial Implementation)”, Available at: https://km sstore.icanmake.cn/1555314460555-TLdfCZaAxHSsM1NP18R75-uz.pdf.
[22] D. Sawada, M. D. Piburn, E. Judson, J. Turley, K. Falconer, R. Benford and I Bloom, “Measuring reform practices in science and mathematics classrooms: The reformed teaching observation protocol”, *School science and mathematics*, vol.102, no.6, pp.245-253, 2002.
[23] J. M. Delaney and P. J. Devereux, “Understanding gender differences in STEM: Evidence from college applications”, *Economics of Education Review*, vol.72, pp.219-238, 2019.

[24] D. Sansone, “Teacher Characteristics, Student Beliefs, and the Gender Gap in STEM Fields”, *Educational Evaluation and Policy Analysis*, vol.41, no.2, pp. 127-144, 2019.
[25] E. E. Blair, R. B. Miller, M. Ong and Y. V. Zastavker, “Undergraduate STEM instructors’ teacher identities and discourses on student gender expression and equity”, *Journal of Engineering Education,* vol.106, no.1, pp.14-43, 2017.
[26] S. Hand, L. Rice and E. Greenlee, “Exploring teachers’ and students’ gender role bias and students’ confidence in STEM fields”, *Social Psychology of Education*, no.*20*, pp.929-945,2017.
[27] A. S. V. Polgampala, H. Shen and F. Huang, “STEM teacher education and professional development and training: Challenges and trends”, *American Journal of Applied Psychology*, vol.6, no.5, pp.93-97, 2017.
[28] M. Milner-Bolotin, “Evidence-Based Research in STEM Teacher Education: From Theory to Practice”, *Frontiers in Education*, no.3, pp.92, 2018.
[29] S. Chamrat, M. Manokarn and J. Thammaprateep, “STEM literacy questionnaire as an instrument for STEM education research field: Development, implementation and utility”, In *AIP Conference Proceedings* (Vol. 2081, No. 1). AIP Publishing, 2019.
[30] K. J. Preacher and A. F. Hayes, “SPSS and SAS procedures for estimating indirect effects in simple mediation models”, *Behavior research methods, instruments, & computers*, no.*36*, pp.717-731, 2004.
[31] L. S. Aiken and S. G. West, Multiple regression: Testing and interpreting interactions. Sage Publications, Inc,1991.
[32] H. Song and M. Zhou, “STEM teachers’ preparation, teaching beliefs, and perceived teaching competence: A multigroup structural equation approach”, *Journal of Science Education and Technology,* no.30, pp.394-407, 2021.
[33] I. DeCoito and P. Myszkal, “Connecting science instruction and teachers’ self-efficacy and beliefs in STEM education”, *Journal of Science Teacher Education*, vol.*29, no.*6, pp.485-503, 2018.
[34] K. P. Goodpaster, O. A. Adedokun and G. C. Weaver, “Teachers’ perceptions of rural STEM teaching: Implications for rural teacher retention”, *The Rural Educator*, vol.33, no.3, 2012.
[35] Y. Hu, Q. Zhang and B. Wu, “Analyzing teaching characteristics and interaction patterns of STEM classroom from the perspective of multi-dimensional evaluation”, *Chinese Journal of Distance Education,* vol.42, no.9, pp.44-52, 2022.
[36] K. Mitchem, D. Wells and J. Wells, “Using evaluation to ensure quality professional development in rural schools”, *Journal of research in rural education*, vol.18, no.2, pp.96-103, 2003.
[37] C. Zhao, W. Zhao and Z. Jiang, “The Design of 5E Inquiry Teaching Model for STEM Education”, *Modern Educational Technology,* vol.29, no.3, pp.106-112, 2018.
[38] H. Z. Okulu and A. Oguz-Unver, “The Development and Evaluation of a Tool to Determine the Characteristics of STEM Activities”, *European Journal of STEM Education*, vol.6, no.1, pp.6, 2021.

[39] A. Sokolowski, *Scientific Inquiry in Mathematics-Theory and Practice*. Springer International Publishing,2018.
[40] Y. Yang and F. Rao, "Case Study and Its Enlightenments on Interdisciplinary Integrated STEM Curriculum Development: A Case of STEM Course in America Mars Education Project", *e-Education Research,* vol.40, no.2, pp.113-122, 2019.
[41] S.YU and X.HU, "STEM Education and Its Model for Interdisciplinary Integration", *Open Education Research,* vol.21, no.4, pp13-22, 2015.
[42] A. Struyf, H. De Loof, J. Boeve-de Pauw and P. Van Petegem, "Students' engagement in different STEM learning environments: integrated STEM education as promising practice?", *International Journal of Science Education*, vol.41,no.10, pp.1387-1407, 2019.
[43] A. L. Lewis, "Putting the "H" in STEAM: Paradigms for modern liberal arts education", *Emerging technologies for STEAM education: Full STEAM ahead*, PP.259-275, 2015.
[44] C. V. McDonald, "STEM Education: A review of the contribution of the disciplines of science, technology, engineering and mathematics", *Science Education International*, vol.*27, no.*4, pp.530-569, 2016.
[45] S. Bevins, "STEM: Moving the liberal arts education into the 21st century", *Technology and Engineering Teacher*, vol. *71,* no. 4, p. 10, 2011.
[46] C. Zuo and Z. Zhu, "Key Points of STEAM Education and Curriculum Reform", Journal of Educational Development, vol. 39, no. 1, pp. 53-60, 2021.