

Sustainable STEM Education for Disadvantaged Communities

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ABSTRACT

Disadvantaged local communities frequently face significant barriers to recognising the value of STEM education and are hesitant to engage in partnerships with external organisations due to mistrust or unfamiliarity. As a result, students from these communities miss opportunities to enhance their learning and career prospects, thereby creating a gap compared to urban students who have better access to innovative programmes, mentorships, and STEM career pathways. This study aims to bridge the gap by exploring the perceptions of disadvantaged communities regarding factors influencing students' performance in STEM education. It also examines their level of involvement in STEM programmes and explores the issues they faced in accessing and engaging with such education. The study involved 11,827 respondents, who were the local communities of 1,224 primary and secondary schools. Using a mixed-methods approach, quantitative data were collected through surveys, and qualitative data were gathered through in-depth interviews. The findings indicate that these communities tend to leave the responsibility for STEM education to teachers, schools, and students. Key obstacles to their partnership include gaps in STEM knowledge, a mindset toward STEM education, and cultural factors that hinder progress in STEM education within disadvantaged communities. Consequently, a local community STEM education model is proposed as a holistic approach to sustaining STEM education by strengthening community support in these communities.

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INTRODUCTION

The rapid adoption of new technologies in the twenty-first-century information age has compelled individuals to acquire the skills necessary for success in a competitive world. STEM education is a gateway to cultivating students' twenty-first-century skills (Huang et al., 2022; Widya et al., 2019). Specifically, STEM education endows learners with essential problem-solving skills, empowering them to contribute meaningfully to society (Pahnke et al., 2019). Furthermore, it equips individuals to navigate and thrive in a dynamic and constantly evolving global landscape. In addition to educational institutions, local communities play a crucial role in STEM education (Hite et al., 2020; Yuenyong, 2019). STEM education has influenced people's daily lives, including the creation of new ideas and solving problems (Vijayatheepan, 2023). Previous studies have demonstrated that community involvement through various programmes positively influences STEM education. The roles of these communities primarily include providing STEM learning environments or acting as collaborators or partners (Hite et al., 2020; So & Guo, 2023).

Rural and interior communities are often disadvantaged compared to urban areas. In lower-middle-income and low-income countries, the rural population constitutes approximately sixty and sixty-seven per cent, respectively (United Nations Department of Economic and Social Affairs [UNDESA], 2021). Therefore, rural development is a critical issue for

these countries. The 19th session of the United Nations Commission on Sustainable Development (CSD) emphasised that economic, social, and environmental factors are crucial for achieving sustainable rural development. Since urban poverty is largely rooted in rural areas, eradicating poverty is essential. The report also underscores the need for approaches tailored to rural settings, considering their remoteness and unique potential (UN General Assembly, 2015). Sustainable Development Goals (SDGs) such as Quality Education, Industry, Innovation, and Infrastructure, Reduced Inequalities, and Partnerships for the Goals are particularly relevant for disadvantaged communities. STEM thinking and science literacy help individuals develop logical, systematic, and critical solutions to problems identified in their communities (Timko et al., 2022).

Community partnerships have bolstered STEM education (Davis & Veenstra, 2014; Lopez et al., 2016), and community-based STEM activities have enhanced students' learning outcomes in STEM subjects (Delaine, 2021). Moreover, STEM community networks and activities make science more appealing and accessible, particularly to students from economically disadvantaged families and underrepresented groups (Davis & Veenstra, 2014). These efforts contribute to the sustainability of STEM education, empower disadvantaged communities to tackle local challenges, and support global sustainability efforts toward achieving several Sustainable Development Goals (SDGs). However, the

quality of STEM education in economically disadvantaged communities, especially in rural and remote areas, still lags that of their urban counterparts (Jones & Cleaver, 2020; Kavanagh et al., 2022; Ling et al., 2021). Beyond being collaborators or partners, communities should take a more active role in STEM education. Key questions include how disadvantaged communities contribute to STEM education and how they can sustain their contributions. Carroll et al. (2019) identified six key factors for the sustainability of STEM education projects: “continuation of activities, sustaining impact, community engagement and collaboration, leadership, planning and evaluation, and finances” (p. 1).

Del Arco et al. (2021) propose that empowering rural populations enables local administrations to formulate community policies that align with institutional objectives, fostering synergies for sustainable development and improving the quality of life. Empowering rural communities allows them to participate, make decisions, negotiate, influence, and exert control, and strengthens their families and productive environments amidst the challenges posed by current socio-economic dynamics (del Arco et al., 2021). Additionally, they assert that quality, inclusive, and equitable education, along with lifelong learning, are integral components of sustainable development that contribute to the growth of sustainable societies (del Arco et al., 2021). Literature also reports that community education models have been proven to benefit disadvantaged communities (SOLAS, 2024). Sustainable STEM education for

disadvantaged communities is crucial for advancing the Sustainable Development Goals (SDGs) and promoting inclusive development. This highlights the importance of community education in effectively contributing to STEM education.

This study aims to explore the perceptions of disadvantaged local communities regarding the factors influencing students' performance in STEM subjects, as provided in the survey instrument; while also investigating the current status of their involvement in STEM education and the issues they face in this field. Based on the literature and the findings, a tailored community education model is proposed to meet the needs of these communities and ensure the sustainability of STEM education.

The significance of this study lies in two main aspects. First, it provides insights into the factors influencing students' performance in STEM subjects, the current level of engagement of disadvantaged local communities in STEM education, and the issues they face. Second, based on these findings and existing community education models, it proposes an innovative education model tailored for disadvantaged communities. This model offers a comprehensive approach to sustaining STEM education within these communities.

LITERATURE REVIEW

Sustainable STEM Education

STEM is an acronym for science (S), technology (T), engineering (E), and mathematics (M). STEM education was

started when engineering and technology were included in science and mathematics for undergraduates and K-12 school education in the 1990s in the United States (Li et al., 2020). There are multiple perspectives on STEM education in the literature. Li et al. (2020) classified it into two perspectives: a broad and inclusive view encompassing education in each STEM discipline, or a focus solely on the interdisciplinary or cross-disciplinary integration of the STEM fields.

In the context of this study, the definition of STEM education is adapted from English (2016), Soo (2019), Sujarwanto et al. (2021), and Liu and Wang (2023). English (2016) suggested STEM education as a context to connect the four disciplines. This approach also aims to blur the barriers between the four disciplines and integrate them into students' daily life to solve daily problems (Soo, 2019). STEM education is an interdisciplinary approach that incorporates the four disciplines, emphasising their interconnections, to prepare students for the advancement of science and technology and equip them with the skills to solve problems (Sujarwanto et al., 2021).

Sustainability refers to the ability to maintain or continue something toward a long-term goal (Timko et al., 2022). "Quality, inclusive, and equitable education", along with lifelong learning, are integral elements of sustainable development that foster the creation of sustainable societies (del Arco et al., 2021, p. 3). STEM education can equip learners with problem-solving skills and enable them to act meaningfully in society (Pahnke et al., 2019). In this study,

sustainable STEM education refers to the ability to continue and maintain STEM education with a focus on sustainability principles, aiming to equip learners with the knowledge and skills necessary to address quality, inclusive, and equitable education, as well as lifelong learning for the sustainable development of disadvantaged communities.

Disadvantaged Local Community

Technically, there is a lack of formal definition of the scope of local community in the education system. Education researchers generally use the term community interchangeably with the stakeholders of the education system, which is generally referring to those who have a stake in the success of the education of the students. Community in most studies on STEM education (Alexandre et al., 2022; Gaias et al., 2022; Jackson et al., 2019; Lim et al., 2022; Newman et al., 2015; Salvetti et al., 2022; Steiner et al., 2019; Sujarwanto et al., 2021) generally includes the schools (students, teachers, administrative staff), families (parents, siblings, and extended families) of the students enrolled in a school, education authorities and policymakers, school alumni, both the education (e.g., parents teacher associations) and non-education related associations, the professional bodies, universities (the undergraduate and graduate students, administrator, and the faculty members), researchers, the non-governmental organisation (NGO), the businesses, and the general residents.

Davis and Veenstra (2014) define the local community as corporations, community groups, and educational institutions supporting STEM education. Great Schools Partnership (2019) refers to the local community as the members of the community who are socially and emotionally attached to a school. The attachments include those that are familial (parents and relatives of students), experiential (the schools' alumni), professional (an individual who works in and whose stipend comes from the school), civic (the caretakers, policymakers, and volunteers of schools), and socioeconomic (the general public who are also the taxpayers, the local businesses whose employees are the schools' alumni and those who share a burden for quality education and betterment of education in the schools). This study resorts to refer community as the local community who are legally, socially, and emotionally attached to the schools. Both terms are used interchangeably in this paper.

Studies show that the local community contributes to the informal STEM education and assists in the enhanced STEM experience (Alexandre et al., 2022; Gaias et al., 2022; Jackson et al., 2019; Lim et al., 2022; Newman et al., 2015; Salvetti et al., 2022; Steiner et al., 2019; Sujarwanto et al., 2021). It plays an important role in enriching the STEM interest and thus the STEM learning of the students. Reed et al. (2022) emphasise that experiences outside the classroom are crucial for fostering and enhancing students' attitudes toward science, regardless of age group. It is thus imperative to build STEM experiences out of the classroom, and this is

the part where the role of community comes in. Alexandre et al. (2022) and Jackson et al. (2019) also reiterate this. According to them, the attitudes, and interests of students in sciences specifically and STEM generally, are collectively influenced by both their formal and informal experiences related to the fields.

The intertwined effect resulting from the students' formal and informal learning of STEM, which took place inside and outside the classroom, is promising. The pertinent role of the community, particularly in fostering informal STEM learning, is well accepted by the STEM education community (Alexandre et al., 2022; Gaias et al., 2022; Jackson et al., 2019; Lim et al., 2022; Newman et al., 2015; Salvetti et al., 2022; Steiner et al., 2019). These studies on the involvement of the community in STEM education have reported a positive impact on student STEM learning (Steiner et al., 2019) and support STEM learning fields (M. Ainley & J. Ainley, 2011).

Nevertheless, the quality and achievement of STEM education among disadvantaged local communities is of particular concern (Jones & Cleaver, 2020; Kavanagh et al., 2022; Ling et al., 2021). The disadvantaged individuals in education generally refer to those who benefit less from the education system than their peers (Organisation for Economic Cooperation and Development [OECD], 2018). In addition to those typically from rural and remote areas, this group of individuals deprived of equal STEM education also includes marginalised individuals

(Galligan, 2008; Ludwig et al., 2024). The marginalised community comprises those discriminated against or isolated from fair access to the education system. This can include individuals suffering from poor health, limited facilities, physical or mental disabilities, financial hardship, social exclusion, and those who are minorities in a community (Galligan, 2008; Ludwig et al., 2024). Studies on informal STEM education with support from the community report encouraging results with improved STEM learning and outcomes among marginalised communities (Ludwig et al., 2024). Consequently, the disadvantaged local community in this study refers to those in rural and remote areas, including the marginalised individuals.

How important is STEM for disadvantaged local communities, particularly in their daily lives and problem-solving? Timko et al. (2022) examine rural communities in the United States on this topic. They report that the communities often relate their daily activities to STEM fields. STEM is perceived as potentially valuable for addressing community challenges, building local partnerships and networks, implementing both formal and informal STEM learning opportunities, and establishing goals to develop a STEM learning ecosystem in rural areas. Their practical applications highlight the significance of STEM thinking and promote a collective understanding of what STEM represents. Timko et al. (2022) highlight that building awareness of STEM and developing related knowledge and skills can benefit individuals in various ways

to address local community challenges, such as improving critical thinking and problem-solving abilities. They also reveal that STEM positively impacts the next generation of learners. They further stress that each community culture is unique, therefore defining local manifestations of STEM that meet the unique needs and identity of individual communities is also important to the sustainable development of STEM learning ecosystems in rural areas.

The studies discussed above imply the importance of sustainable STEM education for disadvantaged local communities. Involvement of the communities in STEM education requires further exploration to gain deeper insights and develop a tailored educational model.

Community Education Model

Community education plays a crucial role in disadvantaged communities, benefiting both individual learners and the broader community (SOLAS, 2024). It is especially efficient in addressing sustainable development challenges such as “Climate Justice Education, Education for Sustainable Development and building Climate Literacy” (p. 18). Due to its inclusive nature, community education unites individuals from diverse backgrounds and experiences, making it especially appealing to those underserved by the traditional “one size fits all” education model, including older learners, people in rural areas, and individuals with disabilities. Moreover, it fosters inclusion by engaging a wide and diverse range of learners (SOLAS,

2024) and significantly impacts equality by providing educational opportunities to disadvantaged learners. Therefore, community education should actively involve disadvantaged learners (AONTAS, 2006).

The concept of community education has evolved differently across contexts due to diverse historical and cultural influences (Zhang & Perkins, 2023). There are various definitions of community education in the literature. According to SOLAS (2004), community education encompasses various meanings, making it difficult to define precisely. Engelbrecht (2005) defines community education as the acquisition of knowledge, values, and skills by people in the community, which has always been the foundation of all human development. Community education is at the heart of human development and has played a vital role throughout the history of social work.

Galligan (2008) characterises community education as a driving force for community development, highlighting its crucial role in tackling social and cultural inequalities, including poverty, discrimination, neglect, and other disadvantages. They point out the challenge of incorporating relevant indigenous paradigms into modern community education practices. Additionally, they emphasise that community education should embody a deep understanding of the intrinsic connection between education and culture (Galligan, 2008). Apart from that, Rubenson (2010) emphasises that community education should be considered

in relation to the different contexts and locations. The researcher suggests viewing community education as an extension of pragmatic educational services aimed at reaching hard-to-access individuals and integrating them into mainstream society through “employment, further education, or rehabilitation” (p. 6).

Ardiwinata and Mulyono (2018) reveal that the concept of community education, which has long been a part of people's lives, is well-established in the realm of science. However, the use of various terms and names poses challenges in creating a cohesive system for community education. As a result, ongoing efforts are being made to define the “basic concepts, evaluations, methods, approaches, and conclusions” (Ardiwinata & Mulyono, 2018, p. 25) associated with community education. The core concept of community education is to offer more educational opportunities for the community. It involves continuous learning processes tailored to the community's needs, designed to prepare and enhance their ability to progress. It also provides community members with the opportunity to actively engage in broader development efforts, benefiting both themselves and the wider community (Ardiwinata & Mulyono, 2018). On the other hand, Zhang and Perkins (2023) define community education as structured lifelong learning for adults aimed at addressing both personal and community needs. The most recent definition by SOLAS (2024) defines community education as both formal and non-formal learning, led by communities for their benefit, to

support “personal, social, educational, environmental, economic, and community development” (p. 12).

Studies on the community education model are very limited. Botari (1996) introduces the Enhanced Community-Centred Education (ECCE) model, which is developed based on previous outreach education models, community needs, and principles such as social and cultural values. The author summarises the relevant literature and concludes with five key principles. First, Values and Goals that emphasises each community has its social and cultural values to sustain while aiming to achieve economic and social goals. Second, Priorities and Plans that emphasise translating the first principle into priorities and plans to establish the educational programme. Third, Administrative Establishment that reiterates the role of communicating and negotiating with educational institutions about suitable programmes. Fourth, Programmes and Support that underscores the need for a support system at both academic and personal levels to optimise the likelihood of community members completing the programme. Lastly, Results and Benefits that reflects the positive outcomes achieved by community members will not only benefit themselves but also contribute to the wellbeing of the community. An additional loop ties the relationships between institutions and education programmes to accommodate the five principles. These relationships involve the community’s contribution, and the benefits gained from the educational programmes (Botari, 1996).

On the other hand, Vijayatheepan (2023) discusses the successful implementation of STEM education involves equipping educators, fostering collaboration with industries, embracing inclusivity, and maintaining adaptability to evolving needs. This suggestion is closely related to the Botari (1996) ECCE model.

The White Paper on Adult Education lists 10 key characteristics of community education (Department of Education and Science, 2000). First, a community education has a non-statutory nature. Second, its rootedness in the community is not just in terms of physical location, but also in that its activists have lived and worked for many years within the community, possessing a deep knowledge and respect for its values, culture, and circumstances, as well as an understanding of community needs and capacity. Third, community education is a problem-solving task with flexible focus based on trust. Fourth, it is a process-oriented rather than syllabus-oriented approach, implying that participants are engaged from the outset as equal partners in identifying needs, designing and implementing programmes, and adapting them on an ongoing basis. Fifth, community education respects the participants and their reflection of their lived experiences. Sixth, it emphasises the concerns with communal values and is committed to aligning curriculum and pedagogy with the needs and interests of students. Seventh, it promotes personalised learning and flexibility within the environment of a learning group, with goals that include not just individual

development but also collective community advancement, especially in marginalised communities. Eight, it emphasises on providing the necessary supports for successful access and learning, particularly guidance, mentoring, continuous feedback and dialogue, childcare, and other related aspects. Ninth, a community education's collective social purpose and inherently political agenda is to promote critical reflection, challenge existing structures, and empower participants to influence the social contexts in which they live. Lastly, it ensures the promotion of participative democracy, recognising a key role for adult education in transforming society.

Galligan (2008) lists four characteristics of the community education model, naming lived experience as the starting point, community education responds to disadvantage and social exclusion, community education works at an individual, community, and political level, and the community group being the deliverer of community education. In addition, Galligan (2008) also identifies four factors influencing the type of programmes for community education, naming accreditation not being a priority for most community groups, requests by the target group, popularity of programmes, and response to an identified need. They share that community education enhances individual self-esteem, confidence, knowledge, and skills. Besides this, it also fosters interaction among community members, enabling them to collaborate on community issues relevant to their specific context. They

observe that community education has successfully engaged marginalised groups and established connections with individuals who are frequently excluded from society.

Community education aims to “create awareness of issues, enhance people’s knowledge, understanding, and skills, influence people’s values and attitudes, and encourage more responsible behaviour” (Department of Irrigation and Drainage [DID], 2012, p. 37-1). DID (2012) also suggests nine characteristics for practical community education projects and concludes that collaboration is the key to successful community education. The nine characteristics include engaging stakeholders and learners, providing a supportive environment, enhancing and reinforcing existing community networks, motivation, offering opportunities to explore beliefs and values, recognising and encouraging positive actions, being pertinent, accessible, and cost-effective, utilising two-way communication, and addressing the community needs. In addition, DID (2012) also highlights eight steps in developing an education programme. The steps are analysing the issue, identifying stakeholders, knowing the target group, determining objectives and outcomes, designing the methods, identifying funding sources, designing and implementing an action plan, and monitoring and evaluating.

A community education charter was established in 2021 based on three key stakeholder pillars - academics, practitioners, and advocacy. It outlines nine core values central to community education

(SOLAS, 2024). These include community education is rooted in equality, justice, and empowerment; it creates a voice for those who are furthest from the education system; it promotes social inclusion in its broadest sense; it is needs-based, driven by the community, and reflective of lived experiences; it recognises the value of both accredited and non-accredited learning; it nurtures critical thinking; it is learner-centred, flexible, supportive, and developmental; it is facilitative, group-focused, and open to new things; and it centres on relationship building.

In this study, community education is viewed as a step-by-step, continuous learning process tailored to the needs and values of disadvantaged local communities. It emphasises community development, particularly in STEM education, to promote sustainable growth within these communities. Each community has unique needs shaped by its specific values. According to Zhang and Perkins (2023), the concept of community education has evolved differently across contexts due to diverse historical and cultural influences. The evidence gathered in this study will be aligned with community education approaches tailored to the specific context of local disadvantaged communities.

METHODOLOGY

Research Design

This study used an exploratory mixed-method design. The quantitative approach was employed to survey local communities' perceptions of the factors influencing

students' performance in STEM subjects. Interviews were conducted to further explore and validate the findings from the quantitative data (Creswell et al., 2003). The qualitative approach aimed to assess the status of disadvantaged local communities' involvement in STEM education and examine the issues related to their participation.

Population and Sampling

The study population consisted of disadvantaged local communities of all 1,224 primary and secondary schools located in rural and interior areas of Sarawak, Malaysia. The sample was selected using a multistage sampling method. First, the population was clustered based on the twelve divisions and thirty education districts. Next, the population was further stratified based on the levels of schools (primary and secondary), and finally, clustered into two categories: urban and rural-interior. The Rural-Interior cluster was selected and further stratified into four strata based on the school location: rural, interior one (P1), interior two (P2), and interior three (P3). The distribution of schools based on location was 11.74% from urban, 59.23% from rural, and 12.34%, 6.94%, and 6.94% from P1, P2, and P3, respectively. The classification of interior areas was based on criteria that included the number and cost of transportation modes, journey risks, water supply, electrical power supply, accommodation, sanitation, telecommunication, healthcare and safety services, and other amenities such as banking

and post offices (Ministry of Education, 2014). The P3 schools were classified as the most challenging.

Samples from the disadvantaged local communities were randomly selected from each division to ensure representative data. The inclusion criteria were individuals residing within the divisions of the selected primary and secondary schools, who were related to the schools in one or another way, aged 18 years and above, and who provided consent to participate in the survey, in-depth interview, or both. Conversely, the exclusion criteria were defined as individuals not meeting the inclusion criteria. All eligible members of these communities were encouraged to participate in the study, and selected survey participants were interviewed. In total, 11,827 respondents from disadvantaged local communities completed the survey, while 957 respondents participated in the in-depth interviews.

Measures

A total of 13 items in the survey instrument were adapted from Schmidt et al. (2009) to measure the extent of factors influencing STEM education. Participants were asked to rate the extent to which these factors influenced STEM education in their community using a 6-point Likert scale (1–no influence, 2–very low influence, 3–low influence, 4–moderate influence, 5–high influence, and 6–very high influence). The instrument had a Cronbach's alpha reliability of 0.93. A structured interview protocol was developed based on the four phases of the Interview Protocol

Refinement (IPR) framework to guide interviewers in collecting high-quality information. This framework improves the reliability of interview protocols (Castillo-Montoya, 2016). The four phases of the IPR framework include ensuring that interview questions align with the study's research questions, organising the interview protocol to facilitate an inquiry-based conversation, having the protocol reviewed by others, and piloting it (Castillo-Montoya, 2016). The interview protocol was further reviewed and validated by a panel of experts in the field. To accommodate community members with different academic backgrounds, particularly those with lower academic levels, the data collection process was assisted by the trained enumerators, who explained the survey items and, where necessary, used the local language.

Data Collection Method

The questionnaire for collecting quantitative data was digitised using Google Forms, which enabled wide dissemination of the survey instrument and made it accessible to respondents across all locations. The survey link was shared with local community representatives in each division, who then distributed it to respondents. For communities in interior areas with limited internet access, printed survey forms were distributed. To collect qualitative data, the researchers visited the selected disadvantaged local communities in the four areas (rural, P1, P2, and P3) to conduct face-to-face interviews. The purpose of the interviews was to confirm

the findings from the quantitative data, explore the current status of disadvantaged local communities' involvement in STEM education, and examine the issues related to their involvement in STEM education.

Data Analysis

Descriptive statistics, such as mean and standard deviation, were used to analyse the quantitative data. The qualitative data were transcribed, coded, and analysed using thematic analysis to identify patterns or themes (Maguire & Delahunt, 2017). Thematic analysis was guided by the factors in the survey instrument, as the qualitative findings were intended to support and complement the quantitative results. A data team was established to conduct the analysis, with the team leader training members in coding. The coded data were first reviewed by the team leader and subsequently discussed and refined together with the research team members.

RESULTS AND DISCUSSION

This section explains the results and discussions, which are further divided into the factors influencing the performance of STEM subjects, current status, issues of disadvantaged local communities' involvement in STEM education, and the Community Education Model. The quantitative data were collected from 11,827 respondents from disadvantaged local communities, including 9,001 (76.11%) respondents from rural communities, 1,128 (9.54%) from P1 communities, 969 (8.19%) from P2 communities, and 729 (6.16%)

from P3 communities. The percentage of respondents decreased in more remote areas with smaller populations. The respondents were from low-income groups, and many had low levels of education or were uneducated. To accommodate community members with lower academic levels, the data collection process was assisted by the trained enumerators, who explained the survey items and, where necessary, used the local language.

In-depth interviews were conducted with 85 local communities, including 41 rural communities, 17 P1 communities, 14 P2 communities, and 13 P3 communities. This selection ensured representation from different locations in each education district. A total of 957 respondents were involved in the in-depth interviews, including 614 interviewees from rural communities, 114 from P1 communities, 83 from P2 communities, and 146 from P3 communities.

Perception of Disadvantaged Local Communities on Factors Influencing STEM Subjects' Performance

The local communities from rural and interior areas perceive all thirteen factors as having a moderate to high level of influence on students' performance in STEM subjects. The factor perceived as most influential is 'Teaching skills' (mean = 5.03, SD = 1.05). This is followed by 'Teachers' enthusiasm' (mean = 4.97, SD = 1.16), 'Teachers' efficacy' (mean = 4.94, SD = 1.06), 'Teachers' knowledge' (mean = 4.96, SD = 1.15), and 'Teachers' attitude towards teaching'

(mean = 4.91, SD = 1.10). The results indicate that teacher-related factors are the top five influences affecting students' performance in STEM subjects. It also indicates that external stakeholders view teacher-related factors as playing a significant role in students' academic performance in STEM subjects.

Disadvantaged local communities also believe that students themselves play a role in their performance in STEM subjects. They perceive the three student-related factors as having a moderate to high influence on students' performance in STEM subjects. These factors are 'Students' interest' (mean = 4.68, SD = 1.21), 'Students' attitude' (mean = 4.66, SD = 1.25), and 'Students' motivation' (mean = 4.66, SD = 1.18). Similar results were found for the three school-related factors, which disadvantaged local communities perceive as having a moderate to high influence on students' performance in STEM subjects. These factors are 'School facilities' (mean = 4.68, SD = 1.21), 'School environment' (mean = 4.66, SD = 1.25), and 'School culture' (mean = 4.66, SD = 1.18). The factors perceived to have less influence compared to others were 'Parental involvement' (mean = 4.20, SD = 1.32) and 'Community involvement' (mean = 4.01, SD = 1.41). The results also show that local communities tend to delegate the responsibility for STEM education to teachers, students, and schools.

The qualitative data provides further explanation for the quantitative findings. Thematic analysis of the qualitative data was organised into three main themes:

perceptions of disadvantaged local communities on factors influencing students' performance in STEM subjects, their current involvement in STEM education, and issues related to community involvement in STEM education. The findings regarding perceptions on factors influencing students' performance in STEM subjects are presented below.

The respondents from the disadvantaged local community delegate their children's STEM education to others. They express that STEM education should be the responsibility of teachers and that students are accountable for their learning. Additionally, they emphasise that schools should have adequate facilities and a conducive environment for STEM learning. One respondent commented:

STEM education should be the teachers' job. Teachers are supposed to teach, and students are supposed to learn. After all, we do not know what STEM education is.

Some communities from rural and interior areas entrust their children's STEM education to schools due to their limited knowledge of STEM. As one parent revealed:

I am not educated. So, I leave it to the school to educate my children. I hope my children will excel in STEM.

These findings are consistent with the study by Allen et al. (2019), which identified similar challenges with the public or communities presuming that the

responsibility for providing STEM education lies entirely with teachers or parents. The researchers also share encouraging findings from their survey, which involved hiring and training local community members who met specific criteria in rural areas to serve as catalysts for students' STEM learning by connecting them with available STEM resources. The opportunities and challenges they highlighted imply the need for a comprehensive and sustainable system to educate disadvantaged local communities and advance students' STEM learning. The studies reviewed indicate that community involvement in STEM education is crucial for enhancing students' STEM learning. These informal STEM learning experiences contribute positively to students' attitudes toward learning STEM concepts (Reed et al., 2022), which in turn positively impacts their interest in STEM (Alexandre et al., 2022; Jackson et al., 2019). Next, the findings about the current involvement of disadvantaged local communities in STEM education are described.

Current Status of Disadvantaged Local Communities' Involvement in STEM Education

Most of the rural and interior communities perceive that STEM is not important in their daily lives, and they cannot relate STEM to their everyday activities. Therefore, they seldom emphasise the importance of STEM to their children. Additionally, they believe they can live without STEM knowledge. In this environment, children in these communities are raised with a mindset and values that indirectly influence their interest

and motivation to learn STEM subjects. As one respondent pointed out:

I cannot relate to STEM in my daily life. We are farmers and go to the farm daily to earn a living. For me, as long as my children can help me work on our farm and earn a living, that is enough for us.

Another respondent disclosed:

The current mindset of the rural community shapes the culture of their community. The younger generation is influenced by this culture, which affects their interest in STEM.

The local communities share that they lack knowledge related to STEM education. They perceive STEM subjects as challenging to learn and worry that their children would struggle to keep up with their studies. They are also unaware of the importance of STEM education. One community member shared:

I felt that STEM subjects were difficult to learn. That is why I couldn't cope with it when I was in school. I hope my child learns these subjects well, but I can't guide him because I have limited knowledge of STEM.

Another respondent noted:

There is not much exposure or awareness among parents, especially those from rural areas. The parents think that if their children can get a job and earn a living in the future, that is good enough.

Although the local community appears to play a passive role in STEM education, the study shows that they indirectly support it. They send their children to STEM activities organised by schools. Some participants provide financial support, while others contribute manpower for STEM activities. They shared:

Since I do not know much about STEM education, I will support the activities by sending my children to participate.

We cannot contribute much to STEM activities, but we can help the schools by preparing food for the children who attend these activities.

The local community does show support for STEM education, as the following comments reveal:

The *ketua kampung* arranges night study sessions for students from 7-9 pm, using the materials provided by teachers.

Parents in our village take turns supervising children with their homework at night, ensuring they complete their assignments, especially in Mathematics and Science.

A parent revealed:

The community is very supportive and cooperative. The School Management Board, especially the priest and PTA, are very supportive, and the Church Board members are very helpful in promoting STEM education.

Some local companies support STEM education through financial contributions for equipment and expenses related to STEM activities. A parent revealed:

Private companies in our area provide support by purchasing furniture and prizes for STEM events organised by the school.

However, Morris et al. (2021) reveal that the live experience of rural students provides them with a rich environment naturally accessible in rural areas for STEM learning. The researchers propose the local rural knowledge model within the rural context to escalate STEM education and uncover more STEM learning opportunities for students in rural areas. Therefore, the responses of the local community members in this study reveal that they are oblivious to the STEM-filled environment readily obtainable within the rural and interior areas. It also indicates the need for the local communities to be educated accordingly and mindfully. Lastly, the findings on issues related to community involvement in STEM education are detailed below.

Issues of Disadvantaged Local Communities' Involvement in STEM Education

The study identifies several issues faced by the disadvantaged local community regarding STEM education. The first issue is that the community does not value the contribution of STEM to their daily lives. There is a negative mindset towards STEM subjects and a local culture that emphasises

art over STEM education. The following excerpts from the qualitative data illustrate these issues:

We are content with our existing culture. I have heard about the importance of STEM education, but changing the local culture is difficult. People prefer to stay in their comfort zone, where they do not believe STEM will influence their lives.

We need significant efforts to change the mindset of people here. We may need intervention programmes from the government, local institutions, or industry. The problem with our community is the lack of industries, and learning institutions are limited to schools.

STEM subjects are difficult. When I was young, my parents and grandparents told me the subjects were challenging. That is why we prefer to pursue fields in the arts and humanities.

Limited knowledge of STEM education is another challenge faced by the disadvantaged local community. The respondents reveal that most people in their community are either illiterate or have low levels of education. Those who are highly educated often move to big cities due to limited job opportunities within the local community. One respondent recalled:

Since most people in our community dislike STEM subjects, our knowledge

of STEM is very limited. We do not know much about it, which is why we are rarely involved in STEM activities, and our community does not organise such events.

Limited experience and a lack of local role models are additional challenges for the disadvantaged local community. The respondents share that their exposure to STEM is limited because most STEM activities are conducted in cities. They also mention the absence of local role models to inspire the younger generation to pursue STEM.

We do not have many opportunities to experience STEM activities. Attending STEM activities in the city is very costly due to the distance. The cost of boat fuel is high, and we cannot afford it.

Since not many people here are successful in the STEM field, we have limited role models in STEM who could motivate our local population.

Due to the geographical context and the limited physical infrastructure available in rural and interior communities for STEM activities, combined with the fact that better-educated individuals have relocated to urban areas for better economic opportunities, there is a pressing need for more community leaders to promote STEM education within these areas. Respondents disclosed:

Most of our educated people are staying in the big city. Therefore, we do not

have educated leaders with STEM knowledge.

Our community is very far from the larger town. Young people who pursue higher education do not return here, which is why we have very few leaders with STEM knowledge.

The responses reported align with the findings of Vuong et al. (2020), which show that STEM academic performance is correlated with family income and the parents' academic qualifications. This correlation helps explain the issues faced by the disadvantaged local communities in supporting their community STEM education, as expressed by the local community members in this study. These communities face a shortage of high-quality STEM education and require STEM enrichment and professional development (Kavanagh et al., 2022). A well-planned STEM initiative by policymakers is needed to address the issues.

A Local Community Education Model

The roles and contributions of the disadvantaged local community in STEM education should be taken into serious consideration in planning STEM education, as their contributions in the literature have significant contributions to STEM education. Their perspectives and life experiences have made valuable contributions to STEM education. However, various issues hinder their full participation, including limited STEM knowledge, mindset, and cultural factors.

The findings indicate that disadvantaged communities in rural and remote areas urgently require an education model tailored to their local context, which aligns with national policymakers' objectives for STEM education. There is a clear need for continuous STEM knowledge development within these communities, which is a turning point for shifting attitudes and improving STEM knowledge.

The proposed model (Figure 1), termed the Local Community STEM Education Model, integrates the five key principles of the ECCE model, the community education characteristics (Department of Education and Science, 2000; Galligan, 2008), the Community Education Charter (SOLAS, 2024), and strategies for successful STEM education implementation (Vijayatheepan, 2023). It also incorporates the findings of this study. The model consists of two main components: the local community and the supporting stakeholders. The community's local government, industrials and private agencies, and local learning institutions are the three key supporting stakeholders in the model, as identified in the studies on which the model is based. The local community component comprises eight steps, which represent the processes required to conduct effective community education. The four steps on the left (blue-coloured rectangles) highlight the main concerns to be decided collaboratively between the local community and the supporting stakeholders, while the four steps on the right (orange-coloured rectangles) encompass the Plan-Do-Check-Act (PDCA)

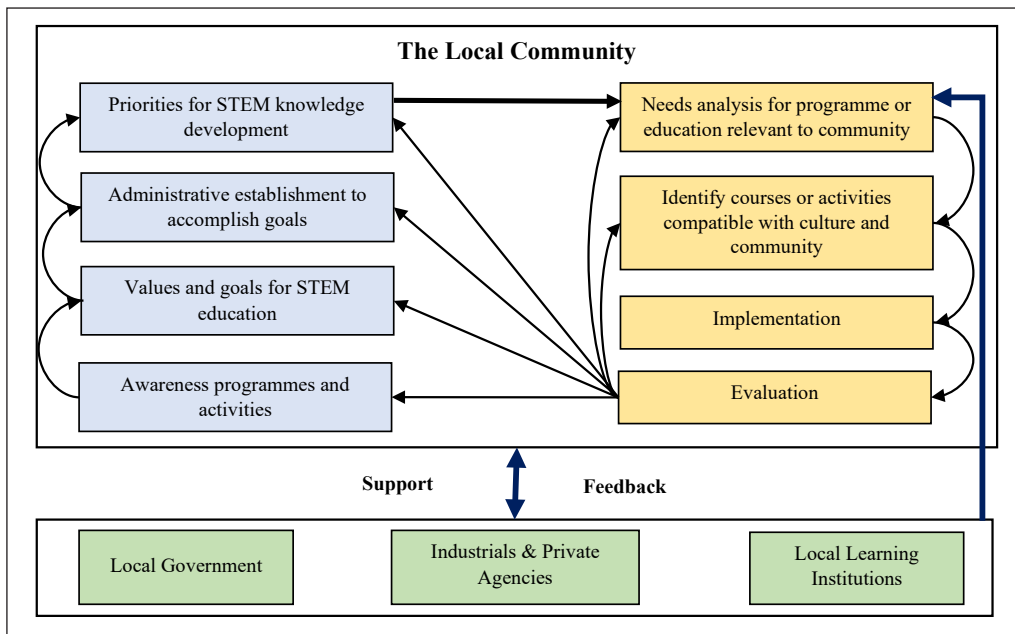


Figure 1. A local community STEM education model

framework, ensuring holistic execution of community education that is contextualised to the local setting and aligned with its goal. The arrows connecting the steps imply that the processes are cyclical rather than linear and may start at any step. Ultimately, the model aims to enhance community support for STEM education by raising awareness of its importance for their children’s future.

To achieve this, the first step (Step 1: Awareness programmes and activities, shown in Figure 1) in the model involves implementing awareness programmes and activities supported by local government, industries, private agencies, and institutions. This step aims to create awareness, as recommended by DID (2012), to change the community’s perception of the value of STEM education.

The findings, particularly those related to perceptions of factors influencing STEM performance, indicate that disadvantaged community is currently unaware of the importance of STEM education.

To initiate the awareness programme, a basic introduction to how STEM contributes to the local community’s daily life will be meaningful (Step 2: Values & goals for stem education, shown in Figure 1). This link is shown by the arrow connecting Step 1 and Step 2. Through activities such as exhibitions and talks, the community can gain a better understanding of the role STEM education plays in their sustainable development. A successful awareness programme can shift community values and goals toward STEM education.

As depicted by the arrow from Step 2 to Step 3, when the community recognises the value of STEM, they are more likely to set clear goals for STEM education and prioritise activities that foster STEM knowledge development among their members (Step 3: Administrative establishment to accomplish goals, shown in Figure 1). The findings on the current involvement of disadvantaged local communities in STEM education suggest that participation increases when communities appreciate the importance of STEM education.

Next, the administrative team should conduct a needs analysis of the community regarding STEM education to identify their priorities for STEM knowledge development (Step 4: Priorities for STEM knowledge development, shown in Figure 1). This process is illustrated by the arrow connecting Step 3 and Step 4. The team may also establish representatives to negotiate with local educational institutions about relevant education programmes and activities.

As depicted by the arrow from Step 4 to Step 5, to help the community prioritise its goals, educational institutions will conduct a needs analysis to identify programmes that will most benefit the community (Step 5: Needs analysis for programme or education relevant to community, shown in Figure 1). Once the analysis is complete, shown by the arrow linking Step 5 and Step 6 (identify courses or activities compatible with culture and community, shown in Figure 1), the community's administrative team will collaborate with institutions, industries, and private agencies to plan,

design, and develop courses or activities tailored to the community's needs and values, emphasising STEM education. The need to work closely with the supporting stakeholders in Step 6 is stressed by the arrow connecting them. The double-headed arrow at the bottom of Figure 1, connecting both components of the model, represents the strong bilateral collaboration required between these stakeholders, communities, and schools to ensure continuous support and feedback for effective community education. The Plan-Do-Check-Act (PDCA) framework, shown by the four processes coloured orange on the right of Figure 1, will be adopted in this model. Ongoing collaboration between the administrative team and educational institutions will facilitate information exchange and address challenges.

The next step is to arrange the delivery of the programme, including selecting the venue (Step 7: Implementation, shown in Figure 1). This process is represented by the arrow joining Step 6 and Step 7. During this implementation stage, schools and learning institutions in the community may support the programme by sharing available resources and facilities, such as providing school spaces for conducting courses. The local government, industries, and private agencies may offer financial support, venues, resources, and facilities necessary for running the courses. Additionally, institutions, schools, and experts from the industrial and private sectors may serve as active partners in delivering the courses.

This collaboration is again depicted by the double-headed arrow connecting the two main components of Figure 1.

As indicated by the double-headed arrow, feedback from the local community to the support group is essential for improving the services and support provided. The success of individual participants will contribute to the overall benefit of the community. At the end of each programme, evaluations should be conducted to assess whether the programme's outcomes align with the community's goals (Step 8: Evaluation, shown in Figure 1), as represented by the arrow connecting Step 7 and Step 8. This evaluation helps identify what is working well and what needs improvement, fostering a cycle of continuous improvement. In the next cycle, awareness programmes can be made more in-depth. The arrows extending from Step 8 to each of the other steps emphasise that the cycle may begin at any relevant step, as shown in Figure 1, and follows a step-by-step approach to building STEM knowledge. With each new cycle, the community's appreciation for STEM education will grow, enabling better-planned activities.

The knowledge gained from this model aims to address and mitigate the issues faced by disadvantaged communities in STEM education. The local community model offers a tailored approach to meet the specific needs and issues of these communities, aligning with global calls for sustainable development, particularly for disadvantaged communities.

CONCLUSION

Numerous studies have affirmed the vital roles and significant contributions of local communities in STEM education. However, many disadvantaged communities still lack sufficient STEM knowledge, and their attitudes toward STEM education need to be improved for full engagement in STEM initiatives. To address the issues, a local community education model is proposed for communities with generally low education levels.

This model aims to enhance STEM education by raising awareness, shifting values towards STEM, and increasing knowledge through activities tailored to the community's needs, as identified in a needs analysis. The Plan-Do-Check-Act (PDCA) framework is adopted to guide the implementation and continuous improvement of the model. The community is encouraged to collaborate with local governments, stakeholders, and educational institutions to strengthen their contributions to STEM education. The model also aligns with the United Nations' Sustainable Development Goals (SDGs), particularly SDG 4 (Quality Education) and SDG 10 (Reduced Inequalities).

Implications of the Study

The findings reveal that disadvantaged local communities do not recognise the importance of their involvement in supporting students' STEM learning and fail to see the relevance of STEM to their daily lives and culture. This disconnect contributes to their reluctance to engage in partnerships that advance STEM

education. It has negatively impacted students' interests and performance. If left unaddressed, this creates a vicious cycle: students remain disengaged from STEM, while communities miss out on its benefits, leading to underachievement and lost opportunities. To break this cycle, communities must be educated on the significance of STEM. The proposed local community STEM education model offers a sustainable approach by implementing tailored interventions designed to disrupt the cycle of underachievement and promote long-term success in STEM education for disadvantaged communities.

Limitations and Recommendations for Future Research

This study is exploratory in nature, with data collected from disadvantaged local communities in Sarawak. The findings are limited to the socio-cultural and educational context from which the data were obtained. Future studies could apply the proposed model to other local communities facing similar STEM education issues, and to validate its effectiveness in comparable environments. Additionally, the community education model could be explored across disadvantaged communities in different regions, with adaptations tailored to the various demographic groups.

Ethics Approval and Consent to Participate

The study involved internal (students, teachers, schools' administrators) and external stakeholders of schools (parents,

alumni, industrial, education experts from schools, universities, and the Ministry of Education). Approval to collect data was obtained from the Ministry of Education Malaysia [KPM.600-3/2/3-eras(7024)] dated 16th March 2020 and Sarawak Education Department [JPNSW.SKPP. LAT.600-1/1/1 Jld.7(47)] dated 23rd June 2020. Consent was also obtained from each participant before they participated in the study.

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