INVENTIVE THINKING AMONG RURAL STUDENTS: A PRELIMINARY RESEARCH

(Pemikiran Inventif Dalam Kalangan Pelajar Luar Bandar: Satu Penyelidikan Awal)

Harizah Aliah Bambang Azhari[1], * Nurul Hijja Mazlan[2], Mohd Zaidi Zeki[3], Nuha Khadijah Najib[4], Riyan Hidayat[5], Nor Zanariah Talib[6]

Submited: 04-Jul-2024
Accepted: 02-Nov-2024
Revised: 02-Dec-2024
Published: 28-Dec-2024

How to cite:
Bambang Azhari, H. A., Mazlan, N. H., Zeki, M. Z., Najib, N. K., Riyan Hidayat, & Talib, N. Z. (2024). Inventive thinking among rural students: a preliminary research: Pemikiran inventif dalam kalangan pelajar luar bandar: satu penyelidikan awal. *ATTARBAWIY: Malaysian Online Journal of Education*, *8*(2), 1–11. https://doi.org/10.53840/attarbawiy.v8i2.221

[1]SMK Bandar Baru Batang Kali,
Seksyen 3, Bandar Utama, Batang Kali,
44300 Batang Kali, Selangor, Malaysia.

[2]Universiti Teknologi MARA,
40450, Shah Alam, Selangor, Malaysia

[3]SMK Seksyen 10
Kota Damansara,
47810 Petaling Jaya, Selangor, Malaysia

[4]Science Physical Program,
Kolej Matrikulasi Selangor,
Kementerian Pendidikan Malaysia, Mukim Jugra,
42700 Banting, Selangor, Malaysia

[5]Faculty of Educational Studies,
Universiti Putra Malaysia, Jalan Universiti 1,
43400 Serdang, Selangor, Malaysia

[6]Institut Aminuddin Baki,
Kementerian Pendidikan Malaysia,
Kompleks Pendidikan Nilai,
71760 Bandar Baru Enstek, Negeri Sembilan, Malaysia

*Corresponding author's email: nurulhijja@uitm.edu.my

Abstract

Inventive thinking is identified as one of the significant skills for addressing 21st-century challenges. This skill serves as a catalyst for the Malaysia government's efforts to nurture innovative and creative culture responding to the digital disruption demands. This effort is aimed to narrow down the inequality gaps between rural and urban areas by fostering quality education and training for citizen. Therefore, this study aims to determine rural students' level of inventive thinking. This study utilized a survey design with instrument is adapted from the Systematic Inventive Thinking Model. Simple random sampling was employed by selecting thirty rural students from Form Four Science stream in Seremban, Negeri Sembilan. This study is significant for assessing students' ability to think inventively. The findings showed that the rural students' level of inventive thinking was moderately low. Therefore, there is a need to foster rural students' inventiveness within the classroom context. Stakeholders are responsible to monitor, strategize, and implement intervention programs to enhance particularly rural students' inventive thinking.

Keywords: inventive thinking, rural students, STEM education, 21st-century skills

Abstrak

Pemikiran inventif dikenal pasti sebagai salah satu kemahiran yang penting untuk menangani cabaran abad ke-21. Kemahiran ini berfungsi sebagai pemangkin

Doi: https://doi.org/10.53840/attarbawiy.v8i2.221

kepada usaha kerajaan Malaysia untuk memupuk budaya inovatif dan kreatif dalam menghadapi tuntutan gangguan digital. Usaha ini bertujuan untuk mengurangkan jurang ketidaksamaan antara kawasan luar bandar dan bandar dengan memupuk pendidikan dan latihan berkualiti untuk rakyat. Oleh itu, kajian ini bertujuan untuk menentukan tahap pemikiran inventif pelajar luar bandar. Kajian ini menggunakan reka bentuk tinjauan dengan instrumen yang diadaptasi daripada Model Pemikiran Inventif Sistematik. Pensampelan rawak mudah telah digunakan dengan memilih tiga puluh pelajar luar bandar dari aliran Sains Tingkatan Empat di Seremban, Negeri Sembilan. Kajian ini adalah penting untuk menilai kebolehan pelajar berfikir secara inventif. Dapatan kajian menunjukkan bahawa tahap pemikiran inventif pelajar luar bandar adalah agak rendah. Oleh itu, terdapat keperluan untuk memupuk pemikiran inventif pelajar luar bandar dalam konteks bilik darjah. Pihak berkepentingan bertanggungjawab untuk memantau, merancang, dan melaksanakan program intervensi untuk meningkatkan pemikiran inventif pelajar luar bandar.
Kata kunci: *pemikiran inventif, murid luar bandar, pendidikan STEM, kemahiran abad ke-21*

1.0 INTRODUCTION

The 21st century ushered in a significant transformation in global civilization, characterized by a surge in technology and information that demanded individuals possess diverse talents and a strong mindset. One of the skills that has been highlighted as a basic need in the 21st century is the ability to think inventively (Ministry of Education Malaysia 2013; Kiong et al. 2018; NCREL and Metiri Group 2003; Noorul Jannah Azaman and Nor Aishah Buang 2019). Inventive thinking is the ability to identify and address creative challenges efficiently (Genrich Altshuller 1990). Inventive thinking must be cultivated at the school level as it is a talent that requires development rather than an innate ability.

Poverty is a pervasive social issue that gives rise to a multitude of concerns on a global scale, including limited access to healthcare, education, and employment prospects (Mazlan et al., 2024). Poverty is, in fact, one of the most significant problems of the 21st century (Kennedy 2000; Martin 2006). According to a report retrieved from Data Asas Malaysia, a disparity in poverty levels between rural and urban residents existed between 1970 and 2014 (KPLB 2015b). In 2014, the disparity between rural and urban residents regarding the monthly income and the poverty rate reached 1.3% and 44%, respectively. In order to mitigate this concern, the Malaysia government has implemented a range of rural policies that promote a culture of innovation and creativity through financial assistance, infrastructural development, and training. This endeavor aims to stimulate economic expansion in rural areas, opening prospects for rural inhabitants to attain a sustainable livelihood (KPLB 2015a).

Ironically, the measure executed by the government to mitigate this problem proves to be less effective. According to the Special Highlights of Entrepreneurship Development 2016 reported by the Small and Medium Enterprises Corporation of Malaysia, the level of culture and innovation among Malaysian is concerning, with the highest percentage occurring in 2009. Moreover, the environment appears less conducive to develop inventive ideas (Saleh, Salmiza, Muhammad, & Abdullah, 2020; Samad, Kamisah, & Osman, 2017; Saleh, Saleh, & Alimah, 2020). Peer pressure, educational system, and instructors' conduct in the classroom impede the development of students' creativity (Mohamad Mohsin and Nasruddin Yunus 2008). As a result, an attempt must be made to foster an innovative and creative culture, such as enhancing inventive thinking skills in school.

Previous studies on inventive thinking have yielded mixed findings- Malaysian students exhibit low (Norhaslinda Abdul Samad and Kamisah Osman 2017), moderate

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(Noorul Jannah Azaman and Nor Aishah Buang 2019) and high levels of inventive thinking (Azizah Mat Ali 2015; Mazliza Mohtar et al. 2018). Specific data pertaining to inventive thinking in rural regions still needs to be explored. In addition, it was found that there was a gap in instruments in previous studies. Most studies that measured inventive thinking are based only on perception (Aliamat Omar Ali 2014; Jamali, Rahman, and Azizan 2015; Masyuniza Yunos 2015; Nur Erwani Rozi 2019). Based on this gap, a study needs to be conducted to measure inventive thinking through the ways of thinking. The level of inventive thinking of rural students needs to be investigated to provide valuable insights into enhancing the teaching quality in accordance with present demands. Therefore, this study aims to investigate the level of inventive thinking among rural students and addressing the following research question- What is the level of inventive thinking among rural students?

2.0 LITERATURE REVIEW

2.1 STEM Learning Among Rural Students

STEM teaching and learning should be conducted through an interdisciplinary, inquiry-based approach that emphasizes hands-on experiences, problem-solving skills, and real-world applications. Effective STEM education moves beyond rote memorization, encouraging students to explore and experiment through project-based learning, which fosters curiosity and innovation. Digital tools and resources also play a critical role in STEM learning, offering simulations, coding exercises, and data analysis opportunities that deepen students' understanding and prepare them for the technological demands of the future. In a relevant study by Hidayat et. al (2024) posits that integrating technology into STEM teaching and learning-specifically Mathematics would assist on comprehending complex concepts. Whilst, learning complex concepts including the STEM concepts through innovative and appropriate pedagogies enhance learning experiences and understanding (Halili et al., 2019). STEM learning among rural students is shaped by unique challenges and opportunities, influenced by limited resources, geographic isolation, and community engagement (Baidya & Jayalakshmi,2024). They found that rural students often face obstacles such as fewer qualified science teachers, reduced access to advanced science courses, and limited exposure to laboratories and up-to-date learning technologies. These limitations can lead to disparities in science achievement and interest compared to urban counterparts.

2.2 Inventive Thinking

Inventive thinking is the ability to creatively, effectively, and strategically solve problems for minimizing trials and errors. Sokol et al. (2008) state that problem-solving involves convergent and divergent thinking. North Central Regional Educational Laboratory (NCREL) and Metiri Group (2003) introduced the Dimension of Inventive Thinking, which consists of six elements: a) self-adaptation and difficulties management, b) self-regulation, c) curiosity, d) creativity, e) courage to take chances, and f) high-level thinking skills.

Adaptation and difficulty management refers to an individual's ability to adapt and change their behavior to align with the present or upcoming circumstances. A person may effectively manage several jobs and demonstrate wisdom while dealing with limitations, including time limits, resources, and systems (NCREL and Metiri Group 2003). Self-regulation enables an individual to cultivate intellectual autonomy, self-regulation, and self-control. Self-regulation is crucial for adapting to the evolving work environment of the 21st century, enabling individuals to adjust to new careers and changing living conditions (Istirahayu, Yusuf, & Mayasari, 2016; Johnston, 2017).

Curiosity is the inclination to seek knowledge through exploration. A strong sense of curiosity is linked to a readiness to exert effort and motivation in exploratory pursuits (Lehwald 1991). Creativity transforms novel and imaginative ideas into reality through cognitive and evolutionary abilities (Malindžák and Buša, 2017). The courage to take risks arises when an individual has recognized the dangers and intends to maximize possibilities while reducing potential risks (Arora and Kumari, 2015; Willick et al., 2017).

The level of Higher Order Thinking Skills (HOTS) applied in Malaysia's educational context aligns with the top four levels of Anderson's Revised Bloom's Taxonomy: applying, analyzing, evaluating, and producing (KPM 2014). HOTS-based learning promotes students to engage in study and investigation while completing challenging exercises that stimulate the mind at an advanced level. Genrich Altshuller (1990) proposed that a person's inventive thinking level is determined by collective thinking skills such as subtraction, multiplication, division, task unification, and attribute dependency. Subtraction skills involve eliminating crucial elements from a product.

Inventive thinking skills among rural students are shaped by various socio-cultural and educational factors. Research indicates that these students often exhibit strong adaptability and creativity, despite facing resource limitations. For instance, a study on Chinese primary school students found that openness to experience significantly enhances inventive and creative thinking, although this effect is more pronounced in urban settings (Chen,2022). Additionally, rural students' educational aspirations and inventive thinking are influenced by their socio-economic backgrounds and the evolving educational landscape (Chen,2022). Teachers in rural areas play a crucial role by employing context-specific teaching methods that cater to the unique needs of their students, thereby fostering an environment conducive to inventive thinking (Syafrial et. al,2022). Overall, while challenges persist, targeted interventions and supportive educational practices can significantly enhance inventive thinking skills among rural students in Asia.

2.3 Sytematic Inventive Thinking

Systematic Inventive Thinking (SIT) was developed the 1990s. SIT is a technique for examining current products or services to create new ones offering more significant advantages. SIT employs human cognitive methods to generate innovative ideas. Boyd (2014) posits that most innovation products are generated when an individual operates within their familiar environment, generating solutions that fail to address challenges. They produce independent solutions to specific problems by employing thinking skills like subtraction, multiplication, division, task unification, and attribute dependency. The SIT technique focuses on two primary aspects of creativity: problem finding and problem-solving. SIT utilizes five thinking patterns introduced by Genrich Altshuller in 1990 during problem-solving activities.

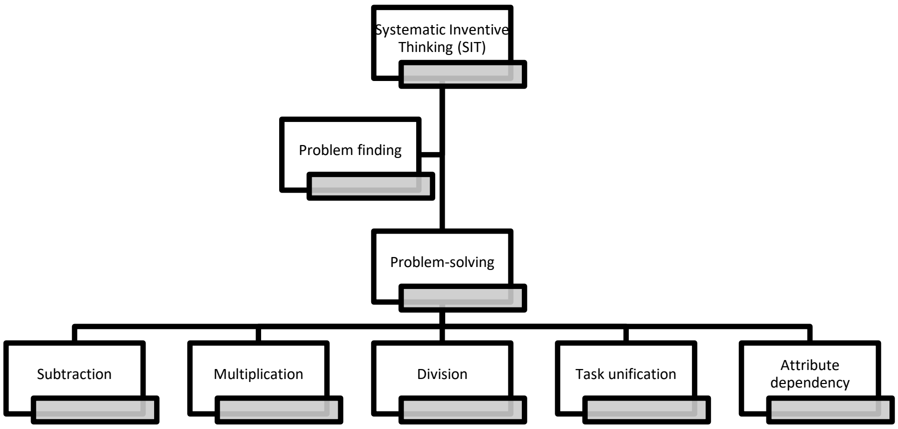

Figure 1 Systematic Inventive Thinking (SIT)

3.0 METHODOLOGY

3.1 Research Design

This study employs quantitative research approach and specifically a survey design. The survey design was selected for its relevance in describing a scenario or occurrence in a population (Radin and Yasin, 2018; Sern et al., 2013). The survey design used is cross-sectional, where data was collected from a single source. The findings offer insight into rural students' present state of inventive thinking skills.

3.2 Sampling

This study was conducted in rural daily secondary schools in Seremban, Negeri Sembilan. Seremban district was selected as the location because it has the highest number of daily schools in Negeri Sembilan. In addition, the locality factor is also considered to access the study location and facilitate the researchers in obtaining data.

This study focused on rural high school students in Negeri Sembilan. Students from rural daily schools were selected due to their typical residence in rural areas. The sample selection is aligned with the aim of the study of eliminating rural poverty through inventive thinking. The study sample comprised thirty Form Four students from science stream. The respondent's ages are controlled as a constant variable due to the correlation between age and level of creativity (Dikici, Özdemir, & Clark, 2018; Stroebe, 2016). The study sample is finalized after 16-year-old students were selected as respondents. They were selected based on the cluster random sampling technique. This approach significantly reduces logistical challenges and costs because researchers can focus on fewer locations or groups while still collecting a representative sample (Thompson, 2012). The sample size was determined based on the analysis of the research design and correlation analysis, which requires a sample size of 30 or more (Ghazali Darussalam 2016).

3.3 Instrument

The researchers adapted the Problem and Solution Test (P&S) created by Barak and Albert in 2017. The SIT inventive thinking patterns were adapted to develop the P&S Test. Two groups were involved in creating the P&S Test. The first group comprised SIT specialists, whereas the second group comprised language teaching professionals (Barak and Albert 2017). The questions from the original P&S Test were translated into Malay and adapted to suit the environmental conditions in Malaysia. The assessment included two open-ended questions, as shown in Figure 2. The respondents' answers were analyzed based on two aspects: the number of problems listed and the number of proposed solutions- regardless of whether they are inventive, conventional, or illogical.

The test sets were given to students and to be completed within 20 minutes. Students must provide personal information and respond to open-ended assessments within a specified time frame. Before the test commenced, the researcher would provide a brief overview of the objective of the test and instruct the students to keep their answers confidential throughout the session.

Doi: https://doi.org/10.53840/attarbawiy.v8i2.221

Figure 2 Research Instrument: Problem and Solution Test

Picture 1 shows a kettle.
Item 1: List as many problems or dangers that may occur when using a kettle.
Item 2: Suggest as many solutions as possible for each problem you listed in Item 1. Give reasons for each of your suggestions.

1. *Scoring Strategy of the Instrument*

The scoring strategy was determined by the P&S scoring rubric presented in Table 1 (Barak and Mesika 2007). The number of relevant problems determined the overall score on Item 1. If the respondent managed to list 20 problems and only 15 were relevant, their score for Item 1 was 15 marks. Item 2 scoring was based on three categories: inventive solutions (I), conventional solutions (K), and irrelevant solutions (TR). Only the solutions to category I problems receive marks, with each correct answer earning 1 mark. The overall score for Item 2 is 3, based on the respondent providing 20 answers to the problem, with 3 inventive, 10 conservative, and 7 irrelevant solutions.

Table 1 P&S Scoring Strategy

Item	Description	Score
1	Number of relevant problems	1 mark for each relevant answer.
2	Type of problem-solving	1 mark for each inventive answer. For example, each suggestion that has elements of subtraction, multiplication, division, task unification and attribute dependency get 2 marks. No marks for each conventional or irrelevant answer.

3.4 Validity and Reliability

The P&S research instrument was translated into Malay language. A Malay teacher with 15 years of teaching experience and a science teacher with 17 years teaching experience; received both the original P&S questions and the translated P&S questions. Based on the teachers' feedback, the revision has been completed involving language structure.

The reliability value of the instrument was determined based on the scoring given by two examiners using the interrater-reliability method. The strategy employed is to determine the correlation between two examiner responses. The initial examiner is the STEM teacher in public school in Malaysia for 10 years and Masters' degree holder in education field. The second examiner is a physics teacher with 25 years of experience and has served as a paper examiner for the Form Three Assessment of Science subject. The researchers refer to the interpretation proposed by Cohen (1988)

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to assess the strength of the relationship (Meier, Brudney, and Bohte 2015). The correlation calculation revealed a good agreement between the two examiners in problem discovery (r=0.91), problem-solving (r=0.85), and inventive thinking level (r=0.91).

4.0 DATA ANALYSIS

Once the score calculation is complete, the score of each element is categorized using the formula in Table 2. Item 1 reflects problem finding, while Item 2 is inventive thinking. This formula and table were adapted from Nur Erwani Rozi (2019).

Table 2 Calculation method of score range and element scoring

Score Range	Score
0	0
0.01 to a	1
(0.01 + a) to 2a	2
(0.01 + 2a) to 3a	3
(0.01 + 3a) to 4a	4
> (0.01 + 4a)	5

$$Element\ mark = \frac{Respondent's\ total\ mark}{Number\ of\ respondents}$$

a Value= (Respondent^' s maximum value,y)/(5 scale)

The score for problem finding and the inventive solution will determine the mean value of inventive thinking. The level of creativity is measured by comparing the mean score with the interpretation provided in Table 3. In Table 3, inventive thinking and scientific creativity are categorized into four levels: low (1.00 to 2.00), moderately low (2.01 to 3.00), moderately high (3.01 to 4.00), and high (4.01 to 5.00).

Table 3 Interpretation of the level of inventive thinking and scientific creativity (Nunnally & Bernstein, 1994)

Mean	Interpretation
1.00 to 2.00	Low
2.01 to 3.00	Moderately low
3.01 to 4.00	Moderately high
4.01 to 5.00	High

$$Inventive\ thinking\ mean\ value = \frac{problem\ finding\ score + problem - solving\ score}{2}$$

5.0 FINDINGS

Rural students' level of inventive thinking is determined based on two elements of SIT: problem finding and problem-solving. Table 4 displays the findings of the analysis for each element of SIT conducted on 30 rural students. According to Table 4, rural students had a mean score of 2.80 for problem discovery, indicating a moderately low level (mean=2.80; sd =1.40). The problem-solving element is at a low level (mean=1.43; sd=1.28). Rural students demonstrated a moderately low level of inventive thinking (mean=2.17; sd =1.14), as indicated in Table 5.

Table 4 Mean and standard deviation for elements in inventive thinking skills of rural students

Inventive Thinking Element	N	Mean	Standard Deviation	Mean Interpretation
Problem finding	30	2.80	1.40	Moderately low
Problem-solving	30	1.43	1.28	Low

Table 5 Mean and standard deviation of the level of inventive thinking skills of rural students

	N	Mean	Standard Deviation	Mean Interpretation
Inventive thinking	30	2.17	1.14	Moderately low

This finding elucidated that students' inadequate performance on the P&S Test can be attributed to a paucity of ideas. Most students can only provide five pertinent responses within 20 minutes. Nine is the maximum score achieved by students. This indicates that even the highest-scoring students require a minimum of two minutes to generate a viable idea. Additionally, some student responses appear similar to other students. Students typically do not generate answers that others have not previously attempted.

6.0 DISCUSSION

According to Dikici et al., (2018) and Stroebe (2016) there is a relationship between creativity and age. Therefore, students must possess highly inventive thinking skills to face 21st century challenges. Researchers believe that limited creative thinking is connected to society's lacking innovative culture. These results align with a report by the Small and Medium Enterprises Corporation of Malaysia (2016), indicating that the level of culture and creativity among Malaysian is low. The approach on teaching and learning of STEM subjects in school settings should be more learner-based with more STEM projects based informal learning structure being implemented. Salmiza Saleh, Azila Muhammad, and Syed Mohamad Syed (2020) concur that enhancement on inventive skills are demonstrated post-implementation of STEM-based learning approach. This approach focused on inquiry and problem solving of the STEM issues among the students in northern region of Malaysia. Echoing the same sentiment, Awofala and Lawal (2022), suggesting that real-life experiences and problems should be introduced during Mathematic instructional hours to enhance understanding and creative thinking that leads to inventive thinking skills.

Researchers believe that the lack of innovative thinking methods in the educational process has contributed to rural students' moderately low level of inventive thinking. Samad, Osman, and Nayan (2023) stated that inventive thinking skills could be fostered through the innovative educators and possibly attracting students to learn STEM subjects in a more two-directional ways in classroom settings. This point of view is supported by research demonstrating that including creative thinking skills in the classroom helps enhance students' creative thinking abilities (Aliamat Omar Ali 2014; Azizah Mat Ali 2015; Barak and Albert 2017). A more flexible approach towards enculturation of inventive thinking skills in classroom settings will be able to enhance the low-level rate of inventive thinking regardless of the location of the schools.

The findings have provided a current picture of inventive thinking among rural students. Findings from this study prove that inventive thinking among rural students is at a moderately low level. Therefore, the findings are expected to increase teachers' motivation to intensify rural students' inventive thinking through effective classroom activities. The researcher believes that the findings will benefit the MoE by improving the curriculum that emphasizes inventive thinking skills so that Malaysia has a high-quality young generation ready to face challenges and able to improve the quality of life. The researcher also hopes that this study can establish cooperation between KPLB and KPM to improve the culture of innovation and creativity in rural communities by inventively improving the way of thinking at the school level. Persistent and continuous efforts are expected to reduce the issue of poverty in rural areas. This study is a preliminary survey; all the data analyzed is based on the findings of the pilot study. Therefore, the number of respondents is restricted. In the future, the study sample can be expanded further. Other variables, such as scientific creativity, scientific knowledge, or curiosity, can also be used to investigate their relationship with inventive thinking. The study will indirectly enhance the effort to increase inventive thinking.

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