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RESEARCH ARTICLE

Boosting Critical Thinking in High School Students with Tech-Based Workshops at SMAN 1 Katapang

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Abstrak

The digital era has transformed societal norms, necessitating critical and solution-based thinking skills to navigate information overload and emerging challenges. This study aims to enhance high school students' critical thinking and problem-solving abilities through technology-based workshops. The program employs a variety of interactive methods, including games, digital modules, online quizzes, and case study analyses, to introduce students to a structured four-step framework: problem identification, solution exploration, solution evaluation, and execution planning. Hands-on sessions with programming platforms like C, along with hardware tools such as Arduino provide practical experience. The results indicate significant improvements in students' abilities to apply critical thinking to real-world problems, fostering proactive behavior and the emergence of local leaders within their communities. The program underscores the necessity of integrating structured problem-solving frameworks into educational curricula to prepare students for future challenges. Recommendations include adopting similar workshops in educational settings to leverage technology for enhancing critical thinking and problem-solving skills.

Keywords: *Critical Thinking, Solution-Based Thinking, Technology-Based Workshops, High School Education, Problem-Solving Skills.*

Introduction

Technology and the internet have transformed society, including thinking and problem-solving methods. Critical and solution-based thinking abilities are imperative for navigating information overload and emerging issues in this digital era [1]. As the younger generation, high school students need to prepare themselves to think critically and discover innovative solutions to real-world problems by capitalizing on available technology and online information.

Solution-based thinking embodies advanced cognitive processes, including systematically identifying problems, critically evaluating potential solutions, and selecting the most effective course of action. These skills are not merely academic exercises but vital competencies for youths to engage meaningfully with real-world challenges and excel in a rapidly evolving digital landscape. Despite its significance, traditional formal education often falls short in cultivating such structured problem-solving abilities, focusing instead on rote learning or theoretical frameworks. This gap underscores the urgent need for initiatives that nurture solution-based thinking as a practical and impactful approach.

Workshops designed around technology-based solution-oriented thinking provide a unique opportunity for high school students to bridge this gap. By leveraging the ubiquity of internet connectivity and personal gadgets, these training programs can immerse students in authentic problem-solving scenarios. This practical exposure not only hones their critical and solution-based thinking capabilities but also instills the confidence and creativity needed to address pressing social and global issues. Equipping students with these essential skills prepares them to navigate the complexities of the digital era with resilience and purpose, enabling them to harness technology for meaningful contributions to society.

Literature Review

A. Akbar, Disman, and Kusnendi (2020) emphasized the importance of problem-solving and problem-based learning approaches in building critical thinking skills in the era of globalization. They demonstrated that these approaches serve as a foundation for preparing students to face global challenges by enhancing analytical and adaptability skills [1]. B. M. Jhon (2021) reinforced this argument through a systematic review on the impact of problem-based learning on critical thinking development. This study highlighted that such approaches significantly improve students' understanding, particularly in decision-making contexts [2]. A. Chevallier (2016) contributed to this discussion by elaborating on the role of strategic thinking in complex problem-solving. This research provided insights into the development of strategic thinking abilities as a key element in addressing real-world problems [3].

A. Zeid (2020) introduced the concept of engineering-based learning applied in STEM education. This study found that integrating engineering into STEM education enhances students' analytical and problem-solving skills [4]. K. Becker and N. Mentzer (2015) supported these findings by highlighting the performance and knowledge outcomes of students in engineering design. They concluded that engineering design not only improves students' technical abilities but also fosters creative and innovative thinking [5]. A. Phan, S. C., and M. L. Dong (2023) proposed a skills-focused curriculum to increase accessibility to problem-solving among high school students. This curriculum was designed to develop specific skills relevant to 21st-century challenges, such as collaboration, creativity, and critical thinking [6].

R. Motschnig, D. Pfeiffer, A. Gawin, P. Gawin, and M. Steiner (2017) presented a case study on transforming learning through interpersonal presence and digital technologies. Their research demonstrated how digital technology can motivate students to actively engage in solving real-world problems [7]. N. Waight and K. Neumann (2020) explored digital ecologies in 21st-century science education. They highlighted the potential of technology in supporting learning while also pointing out challenges such as access disparities and the need for relevant pedagogical development [8].

This literature review demonstrates that problem-based approaches, engineering integration, skills-focused curriculum development, and the utilization of digital technologies play critical roles in creating an adaptive learning ecosystem for the 21st century. These studies provide a strong theoretical foundation for the development of educational innovations focusing on critical, strategic, and technical skill development for students.

Methodology

Theoretical Delivery

In the theoretical delivery session, the facilitators first introduce various technological tools to aid the solution-based thinking process, such as programming platforms like Scratch and Python, hardware sensors and boards like Arduino and digital applications. A range of studies have explored the use of problem-solving frameworks and thinking tools emphasize [6] the importance of a systematic approach, with Chevallier's four-step framework focusing on problem identification, solution exploration, solution evaluation, and execution planning. The facilitators then explain in detail a four-step solution-based thinking framework: problem identification, solution exploration, solution evaluation, and execution planning. Each phase is elaborated comprehensively, along with examples to provide a systematic problem-solving methodology.

Practical Delivery

The research [7] emphasizes the importance of hands-on, practical learning experiences in design and technology education. These experiences allow students to develop problem-solving skills and apply their knowledge in real-world contexts. Reference [8] further highlight the potential of digital technologies in enhancing these experiences, particularly in the context of environmental education and science assessment. These technologies can provide new ways of engaging students and promoting more effective learning.

During hands-on practical sessions, participants can directly experiment with technologies introduced previously, including coding languages, electronic devices, and digital applications. Facilitators guide students as they explore key features and potential use cases. By tinkering with fundamental tools, students obtain first-hand experience that builds familiarity with available problem-solving resources. Students are then guided to actively identify issues around their environment at home or school to crystallize real-world problems worth solving.

Case-Based Delivery

In the case-based module, students analyze complex issues through multifaceted real-world cases that delve into a diverse range of scenarios, including business challenges, social problems, and ethical dilemmas. These rich, detailed case studies enable students to comprehend the logical flow of events, identify key stakeholders, understand critical decision points, and uncover potential innovation opportunities.

By contextualizing the solution-based thinking frameworks into these narrative cases, students grasp how methodical analysis can trace problems back to their underlying systemic causes, even in intricate real-world situations. This approach helps students develop a deeper understanding of how to apply structured problem-solving techniques to address complex, multifaceted issues in practical settings.

Figure 1. Educational Delivery Methodology

Evaluation

In self-directed assignments, students freely select issues they feel passionate about based on their personal experiences and interests. They then conceptualize solutions by applying the systematic problem-solving frameworks provided during the training program.

Constructive feedback from their peers and the program facilitators, which focuses on the potential of the proposed solutions rather than just the accuracy, provides positive reinforcement that maintains the students' motivation to continually enhance their solutions. This cultivation of self-directed learning habits helps sustain the students' engagement, enabling them to persistently improve their critical thinking and problem-solving abilities over time.

Solution-Based Thinking Process

The solution-based thinking training program carefully scaffolds analytical concepts and tools to align with the developmental capacities of teenage learners. While the core critical thinking principles encompass complex real-world analysis, the program utilizes vocabulary, examples, and assignments that are explicitly tailored to the needs and abilities of high school students, rather than employing advanced methodologies more suitable for older or more experienced learners.

By adapting the content and delivery to the specific learning styles and cognitive levels of the target audience, the program aims to make the principles of solution-based thinking accessible and engaging for its high school participants.

A range of studies have explored the challenges and potential solutions for teaching problem-solving skills to high school students. In the articles [2] and [3] both emphasize the importance of hands-on, practical learning experiences, with Phan specifically focusing on the use of problem-solving tools and heuristics. In the other research [4] and [5] highlight the need for students to develop a deeper understanding of problems and to critically evaluate potential solutions. Becker's research revealed that high school students frequently encounter difficulties in scoping problems and assessing alternative solutions.

The solution-based thinking principles, which include methodical problem identification, solution exploration, and critical evaluation, can prove abstract for high schoolers unfamiliar with such structured analysis. Hence, we recognize the necessity of presenting these techniques in an engaging, yet uncomplicated manner suited to students' learning capacities. Our field observations reveal that directly exposing students to problem-solving frameworks often intimidates them due to the sheer seriousness of structured critical thinking. Therefore, interactive games, digital modules, and activities scaffold the core training content to catalyze interest without diluting key ideas. For instance, we develop online quizzes and weekly technology-mediated challenges to incentivize regular engagement channels.

Gamifying modules maintain enthusiasm, while case study analyses enable students to connect abstract concepts to relatable contexts. Current affairs and neighborhood scenarios facilitate framing solution-based thinking as valuable life skills rather than theoretical principles. While sustaining student motivation via multimedia components, we continually emphasize the methodical thought process through repetitive reinforcement.

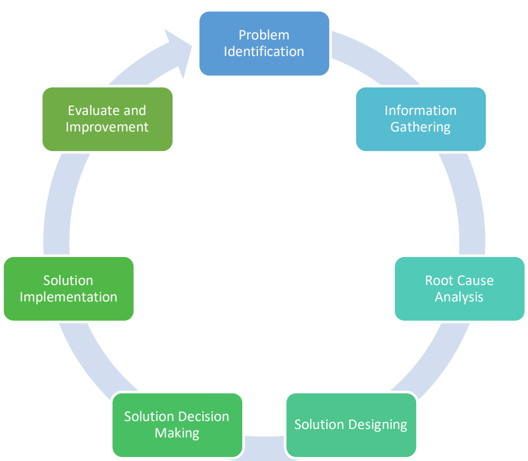

Figure 2. Solution-based Thinking Process

Problem Identification Phase

In the theoretical delivery session, the facilitators first introduce various technological tools to aid the solution-based thinking process, such as programming platforms like Scratch and Python, hardware sensors and boards like Arduino and digital applications. A range of studies have explored the use of problem-solving frameworks and thinking tools emphasize [6] the importance of a systematic approach, with Chevallier's four-step framework focusing on problem identification, solution exploration, solution evaluation, and execution planning.

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Information Gathering Phase

Student groups utilize a range of research methods to thoroughly investigate their assigned perspectives on the identified problem. They conduct systematic ethnographic observations to gain deep insights into real-world contexts, complement that with contextual interviews of sample users to understand their needs and experiences, and perform comparative testing of relevant applications to assess technical capabilities and limitations.

Additionally, they undertake comprehensive literature reviews to situate the problem within existing academic and industry knowledge and carry out quantitative data analysis via surveys to gather quantifiable insights on factors such as environmental impact and accessibility barriers. The groups then collate all their findings, including literature, testing data, videos, and interview transcripts, on a shared drive for collaborative analysis and synthesis.

Root Cause Analysis Phase

A structured "Three Whys" questioning template guides student discourse to dive deeper, moving from identifying surface-level issues to examining causal relationships and pinpointing underlying root triggers. Facilitators provide cues to help students connect the gathered information components, drilling down through a series of driver-questions that encourage deeper reflection. This process enables students to articulate their analysis by causal diagrams, which visually represent the complex web of factors contributing to the problem at hand.

Solution Design Phase

The solution design phase necessitates radical thinking to craft targeted strategies addressing the root causes of previously identified community issues rather than mere symptomatic fixes. It involves deep-diving analysis into the problems' core contributing factors and systemic obstacles underpinning them. For instance, to tackle rampant school dropouts, trace the originating drivers like poverty, educational access limitations, and restrictive sociocultural norms.

Comprehending the primary causations enables designing impactful interventions - providing need-based scholarships, boosting infrastructure in underserved areas, or launching anti-discrimination drives. Such transformative solutions create enduring change by removing structural barriers hindering progress. Continuous evaluation and adaptation also help optimize program effectiveness and align with evolving contexts. In essence, incorporating radical thinking allows conceiving ambitious, long-term strategies striking at the heart of challenges instead of superficial, reactionary measures during solution planning, facilitating a more sweeping, systemic community impact.

Solution Decision-Making Phase

Groups assess peer solution visions displayed in a science fair format using flexible evaluation criteria considering the degree of root issue resolution, extent of creative application of available technologies, demonstrated understanding of users' needs, and components requiring external support for execution. Following structured deliberation, teams vote democratically to select the optimal solution prototype for further development. The first stage in this methodology is problem identification, where the issues faced by society are identified.

At this stage, initial observations and general data collection are conducted to determine the most urgent and significant problems. Once the problem has been identified, the next step is to gather detailed information about it. This can be done through methods such as interviews, surveys, focus group discussions, and literature reviews. The collected information is then analyzed to determine the root cause of the problem. Analysis techniques like fishbone diagrams (Ishikawa), the 5-Why method, or other relevant approaches are employed to ensure that the solution addresses not only the symptoms but also the underlying cause of the problem.

After identifying the root cause, the next phase involves designing a specific and measurable solution. The designed solutions must align with the needs and capacities of the community while considering the available resources. Various alternative solutions are then evaluated and selected based on specific criteria, such as effectiveness, efficiency, cost, and long-term impact.

Once a decision is made, the chosen solution is implemented in the field. The implementation process should be well-planned, including task division, resource allocation, and activity scheduling. Finally, the last phase involves evaluating the outcomes of the implemented solution. The evaluation is carried out to measure the effectiveness of the solution in addressing the identified problems. Based on the evaluation results, improvements and refinements are made to ensure that the positive impact continues to grow.

Through this systematic and participatory approach, it is hoped that the resulting solutions will not only be effective in overcoming existing problems, but also sustainable and empowering communities to continue to develop.

Implementation Planning Phase

An expanding checklist template supports systematic considerations of incremental milestones towards executing the chosen solution - funding requirements for scalable operations, skills development for passage of capability building, pilot testing for capability validation, result indicators, and monitoring mechanisms. Early teacher inputs guide teams in developing holistic advancement visualizations implemented flexibly using preferred pictorial or diagrammatic planning styles.

Evaluation and Improvement Phase

The evaluation and improvement process of student work and progress is facilitated through the guidance and coaching provided by teachers/lecturers. Throughout the learning process, teachers give feedback, suggestions, and direction to help students identify areas where improvement is needed and support them in making those improvements.

Result and Discussion

Result

The community service program yielded significant outcomes, demonstrating the effectiveness of solution-based thinking workshops for high school students. The program successfully engaged students through a diverse range of activities designed to enhance their critical thinking and problem-solving skills using technology and internet-based tools.

Figure 3. Class Situation

The mentoring process included various activities such as interactive games, digital modules, online quizzes, technology-mediated challenges, and case study analyses. These activities ensured that students could grasp complex concepts and apply them in real-world contexts. The combination of theoretical and practical sessions was particularly effective in maintaining student interest and motivation.

Students were introduced to programming platforms like Scratch and Python, hardware sensors and boards like Arduino, and various digital applications. Facilitators guided students through a structured four-step solution-based thinking framework: problem identification, solution exploration, solution evaluation, and execution planning. Hands-on practical sessions allowed students to experiment with these technologies, gaining first-hand experience and familiarity with problem-solving resources.

Figure 4. Studying Process

The program led to several positive social changes. Students developed a heightened awareness of the importance of critical thinking and problem-solving in the digital era, which translated into proactive behavior in identifying and addressing community issues. The workshops also facilitated the emergence of local leaders among the students, who took initiative in collaborative projects and motivated their peers. Overall, the program fostered a new social norm that emphasized innovation, collaboration, and the responsible use of technology for social good.

Figure 5. Student Appreciation

Discussion

The community service program's results align with theoretical perspectives on the importance of critical thinking and problem-solving skills in education. The integration of technology and internet-based tools into the curriculum proved effective in engaging students and enhancing their learning experiences. This chart presents the responses from a community service questionnaire, highlighting participants' feedback on various aspects of the event. Each bar represents the total number of responses for each question, categorized into "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree."

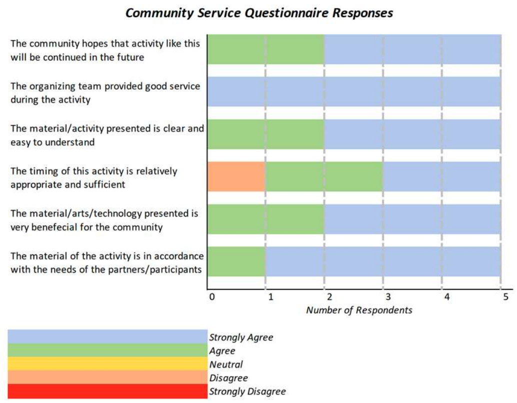

Figure 6. Community Service Questionaire Result

The findings support the theoretical view that structured problem-solving frameworks are essential for developing higher-order cognitive skills. The program's success highlights the necessity of incorporating such frameworks into educational curricula to prepare students for future challenges. The overwhelmingly positive responses, particularly in the "Agree" and "Strongly Agree" categories, indicate that the theoretical aspects of the event were well-received. This supports the idea that structured problem-solving frameworks and technology-based learning can significantly enhance participants' understanding and skills. The questions related to the clarity of the material and the usefulness of the technology demonstrate that participants found the theoretical content clear, relevant, and beneficial.

The practical implementation of the solution-based thinking workshops demonstrated that such programs could be effectively integrated into high school education. The use of interactive and engaging methods, such as gamified modules and case-based learning, maintained student motivation and interest. This program's framework can serve as a model for similar initiatives aimed at enhancing students' critical thinking and problem-solving abilities. The practical success of the event is evidenced by the high level of satisfaction with the implementation details, such as the alignment of activities with participant needs and the quality of the organizers' support. The responses show that the participants valued the hands-on activities and the practical applications of the theoretical concepts taught. The positive feedback on the timeliness and the smooth execution of the event suggests that the practical arrangements were effective and appreciated.

Gambar 7. Student Participation

Conclusion

The community service program effectively enriched high school students' critical and solution-based thinking skills using technology and internet-based tools. The workshops equipped students with the necessary skills to navigate the digital era and address real-world problems innovatively.

The program confirmed that structured problem-solving frameworks are vital for developing higher-order cognitive skills. The success of the program suggests that incorporating these frameworks into educational curricula can significantly enhance students' readiness to tackle future challenges.

Educational institutions should adopt similar solution-based thinking workshops to foster critical thinking and problem-solving skills among students. Future programs should continue leveraging technology and internet-based tools to engage students and provide practical, hands-on learning experiences. Additionally, ongoing evaluation and adaptation of the program's framework will ensure its continued relevance and effectiveness in a rapidly evolving digital landscape.

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