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SWOT analysis to assess implementation of medicinal plants and its development based on the perceptions of teachers and stakeholders

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ABSTRACT

Education about medicinal plants facilitates the development of scientific research skills, including field data collection, laboratory analysis, and the writing of research reports in line with the developments in 21st-century education, which emphasize knowledge-based skills. This research aims to evaluate the implementation of biology education with the integration of medicinal plant materials in an effort to harness local potential, viewed from the perspectives of educators and policy stakeholders using SWOT analysis. This study employs a qualitative research approach with a case study design, allowing for an in-depth understanding of the implementation of biology education and the prospects for the development of medicinal plant materials in several schools. Qualitative research methods provide a profound insight into the implementation of biology education, the prospects for the development of medicinal plant materials, and the identification of factors influencing its implementation. The research was conducted in senior high schools (SMA) in Karanganyar. School selection was done purposively, considering variables such as the level of implementation success, geographical location, and student population diversity. Research participants include Biology teachers, students, and education policy stakeholders. The research results provide valuable insights into how education about medicinal plants can influence students' understanding of biodiversity, ecosystem roles, as well as environmental and cultural impacts. Furthermore, this research has identified challenges and opportunities in integrating medicinal plant materials into biology learning.

Keywords: development; medicinal plants; perceptions; Karanganyar; SWOT.

1. INTRODUCTION

Learning about medicinal plants helps students understand important concepts about biodiversity and its crucial role in ecosystems (Affandy et al., 2024a; Ervina & Mulyono, 2019). Learning about medicinal plants also enables students to grasp the impacts of environmental changes on flora and fauna (Kusumadani et al., 2024; Munadi, 2017). Learning about medicinal plants allows students to develop scientific research skills (Siskawati, 2021), including field data collection, laboratory analysis, and research report writing (Affandy et al., 2019; Pratiwi et al., 2019). The abundance of medicinal plants in nature creates opportunities to address issues of natural conservation and species protection (Affandy et al., 2019; Jiménez-Balam et al., 2019). Students can comprehend how excessive exploitation of specific medicinal plants can threaten human survival (Affandy et al., 2024b; Sheikhrabori et al., 2017). Learning about medicinal plants is also relevant in the context of human well-being. Students can understand how medicinal plants have been used in various cultures to treat diseases, improve the quality of life, and maintain holistic health (Linger, 2017). Thus, learning about medicinal plants is consistent with the developments in 21st-century education that emphasize knowledge-based skills.

Medicinal plants have been used for centuries for medical purposes (Cahyaningsih, Phillips, et al., 2021; Ervina & Mulyono, 2019; Paryadi, 2017). Teaching students about medicinal plants can assist in understanding the fundamentals of medical science, such as organic chemistry, phytochemistry, and relevant extraction processes used in the production of natural medicines. Medicinal plants contain various chemical compounds that can be used to comprehend organic chemistry concepts, chemical reactions, and chemical analysis. Students can learn how these compounds are extracted, isolated, and identified (Affandy et al., 2019; Pratiwi et al., 2019). In the modern era, this understanding remains relevant in the development of new plant-based medicines and alternative treatments.

Indonesia is known as a living laboratory for global biodiversity, especially in terms of medicinal plants (Cahyaningsih, Phillips, et al., 2021; Ervina & Mulyono, 2019; Paryadi, 2017). Indonesia possesses approximately 30,000 types of plants with potential medicinal properties (Abrori, 2021; Cahyaningsih, Phillips, et al., 2021; Ramadani et al., 2018). This number encompasses a significant portion of the total 40,000 known medicinal plant species worldwide (Budiarti et al., 2020; Cahyaningsih, Magos Brehm, et al., 2021; Ramadani et al., 2018). The diverse biodiversity of medicinal plants in Indonesia creates immense potential for research and the development of natural medicines.

Indonesia has a long history of using medicinal plants in traditional medicine. Knowledge about the use of medicinal plants has been passed down from generation to generation (Arfianawati et al., 2016). The utilization of medicinal plants in Indonesia has become an integral part of the culture and traditions of its people (Budiarti et al., 2020). Traditional healing with "jamu," herbal concoctions, and natural remedies has been employed for centuries to address various health issues (Kemenperin, 2014). Some medicinal plants have successfully evolved into modern herbal medicines produced on a large scale. Examples include plants like "*temulawak*" (*Javanese ginger*), *turmeric, ginger*, and "*kencur*" (*lesser galangal*), which are used in various herbal products and supplements.

Incorporating instructional material on the use of medicinal plants in biology education has significant potential to enrich students' understanding of biological concepts while exploring the vital importance of biodiversity and the use of plants in traditional and modern medicine (Awad & Al-Shaye, 2014; Xiong et al., 2020). Medicinal plant material can introduce students to the concept of biodiversity and teach them to recognize various plant species used in traditional and modern medicine (Xiong et al., 2020). Medicinal plant material can also acquaint students with ongoing research in the field of plant-based pharmacy. Learning about medicinal plants can also teach students how to harness local resources for treatment and natural remedies, promoting awareness of local culture and traditions. Thus, integrating medicinal plant material into biology education can provide students with a deeper understanding of the relationship between biodiversity, plant

biology, and human usage. It can also stimulate their interest in scientific research and environmental conservation.

The implementation of biology education with a focus on understanding medicinal plants may encounter several challenges. (1) Finding appropriate and relevant learning resources on medicinal plants, especially those aligned with the curriculum and students' comprehension levels, can be difficult (Hossain et al., 2021). (2) Teaching students to recognize various medicinal plant species can be challenging, particularly if students lack prior experience in botany (Linger, 2017). (3) Conveying to students the science behind the effects and uses of medicinal plants requires a deep scientific understanding (Sheikhrabori et al., 2017). (4) In the case of teaching about medicinal plants, there are many botanical and chemical terms that may be challenging for students to grasp, especially if their native language is not English or another commonly used language in science (Xiong et al., 2020). (5) Understanding traditional medicine, culture, and beliefs related to medicinal plants is also an essential aspect of the learning process (Nanjala et al., 2022). (6) Schools and teachers may have limitations in resources for gathering medicinal plants or conducting experiments in biology teaching, potentially restricting students' practical experiences (Rana et al., 2019). (7) Teaching the use of medicinal plants should also encompass safety and ethics aspects in natural medicine usage (Ahmed et al., 2023). To address these challenges, it is crucial to design learning programs that align with students' comprehension levels, incorporate high-quality resources, and leverage innovative teaching methods and technology. Additionally, collaborating with experts in botany, pharmacy, or ethnobotany can enrich students' learning experiences and provide deeper insights into medicinal plants.

The study results (Cahyaningsih, Phillips, et al., 2021; Xiong et al., 2020) have underscored the importance of the diversity of medicinal plants in various cultures and environments. Medicinal plants not only hold medical value but also possess ecological and cultural significance (Jiménez-Balam et al., 2019). Therefore, integrating medicinal plant material into biology education can help students understand their value and vital roles in human life and ecosystems. The research findings align with (Zaidi et al., 2022) studies indicating that many medicinal plants have significant therapeutic potential. Integrating medicinal plant material into biology education can enable students to comprehend the chemical and biological properties of these plants and their potential in healthcare and maintenance of well-being.

Previous research (Cahyaningsih, Phillips, et al., 2021; Xiong et al., 2020) outcomes have emphasized the importance of conserving medicinal plants and efforts to preserve biodiversity. Integrating medicinal plant material into the biology curriculum can help students understand the challenges and strategies involved in preserving these plants, as well as the ecological impacts of overexploitation. The integration of medicinal plant material into biology education can make learning more engaging and relevant for students (Zaidi et al., 2022). Studying medicinal plants can allow students to engage in practical experiments, field studies, and gain a deeper contextual understanding (Jiménez-Balam et al., 2019).

However, to optimize the effectiveness of this method, further research is needed to identify the best strategies, suitable learning tools, and effective approaches for integrating medicinal plants into the biology curriculum. Further research in this regard can provide valuable insights and guidance for educators and education policymakers. The research findings can be used to enhance the biology curriculum and develop more innovative and effective teaching models.

2. METHODOLOGY

The research employed a qualitative approach with a case study research design (Creswell, 2012). The case study method allowed for an in-depth exploration of the implementation of biology education and the prospects for the development of medicinal plant materials in several schools, while the qualitative approach provided flexibility to explore the perspectives and experiences of educators, students, and relevant stakeholders. Qualitative research methods provided a profound understanding of the implementation of biology education and the prospects for the development

of medicinal plant materials (Creswell, 2012), as well as identifying factors influencing its implementation through SWOT analysis. Therefore, this research is expected to offer practical guidance for enhancing more effective and efficient biology education.

This study was conducted in senior high schools (SMA) located in Karanganyar. School selection was purposeful, taking into consideration variables such as the level of implementation success, geographic location, and student population diversity. Research participants included Biology teachers actively involved in teaching at the selected schools, students from biology classes who had undergone the learning process, and stakeholders involved in educational decision-making at the school and district levels.

The research instruments used in this study were interviews, observations, and document analysis. Semi-structured interviews were conducted with Biology teachers, students, and stakeholders to explore their perspectives and experiences related to the implementation of biology education and the prospects for the development of medicinal plant materials. Direct observations were utilized to examine how the implementation of learning occurred within biology classrooms. Documents such as lesson plans, teaching materials, and learning evaluation results were analyzed to identify strengths and weaknesses.

Qualitative data obtained from interviews, observations, and document analysis were analyzed using a content analysis approach. Findings were categorized into strengths, weaknesses, opportunities, and threats, commonly known as the SWOT analysis acronym (Puyt et al., 2023). To ensure the validity and reliability of the research, data triangulation was employed, and peer researchers were asked to conduct cross-validation of the analysis performed. The research adhered to all research ethics principles, including obtaining permission from schools and informed consent from participants.

3. RESULTS AND DISCUSSION

An evaluation study of the implementation of biology education that integrates medicinal plant materials in an effort to harness local potential can be analyzed using the SWOT approach. The results of the SWOT analysis can provide valuable insights to educators and policymakers in developing and improving approaches to integrating medicinal plant materials into biology education. The findings from the SWOT analysis can also help formulate an effective learning model to address challenges and capitalize on existing opportunities. The research results and discussions are presented in the following subsections.

3.1 Strengths

Strengths are conditions that serve as an advantage within an organization (Puyt et al., 2023). These strength factors represent a comparative advantage within an organization (Puyt et al., 2023). These strength factors are a plus or a comparative advantage of an organization. The strengths referred to in this research are the advantages or something reciprocal related to the implementation of biology education and the prospects for the development of medicinal plant materials in schools.

Based on the observations regarding the advantages of implementing biology education at the high school level in Karanganyar, it was found that biology education can create: (1) effective teaching and learning activities (Sakir & Kim, 2020), (2) increased student engagement (O'Neil et al., 2020), (3) comprehensive assessment (Balta & Asikainen, 2019), and (4) enhanced student development (O'Neil et al., 2020). The observational findings align with research results indicating that the implementation of biology education at the high school level has a significant positive impact on various aspects of education. The research results (Oliveras et al., 2013) demonstrate that effective biology teaching at the high school level can lead to effective teaching and learning activities. Teachers who apply teaching strategies aligned with the curriculum and students' needs can optimize the understanding of biology subject matter (Botstein & Bialek, 2004). The

implementation of interactive and participatory biology education encourages students to be more active in the learning process (Sakir & Kim, 2020). Students become more willing to participate in classroom discussions, ask questions, and engage in practical activities (Arsad et al., 2011).

The observational findings align with the interview results from Biology teachers (BT1 & BT2) who stated:

"*The independent curriculum encourages biology teaching that is more oriented towards practical experiences. Students can engage in field activities, experiments, and projects that focus on a direct understanding of environmental issues, such as monitoring local ecosystems or analyzing the impacts of climate change.*" (BT1)

"*The independent curriculum enables more interdisciplinary biology teaching. Environmental issues often involve concepts from various subjects like chemistry, geology, and ecology. The independent curriculum allows for the integration of these concepts within the context of biology.*" (BT2)

Statements from Teacher 1 and Teacher 2 discuss the expected impacts of implementing the independent curriculum in biology education. Teacher 1 mentions that the independent curriculum will encourage biology teaching that is more oriented towards practical experiences. Teacher 2 highlights that the independent curriculum allows for more interdisciplinary biology teaching. This means that students will not only study biology as a separate subject but will also integrate concepts from various other subjects like chemistry, geology, and ecology.

The key common points based on both teachers are: (1) The independent curriculum can help connect biology teaching to important environmental issues. (2) Both statements emphasize the importance of practical experience and direct interaction with the subject matter. The independent curriculum prioritizes active learning, which can enhance student engagement and understanding. (3) Both teachers highlight the importance of integrating various subjects, reflecting the complexity of environmental issues, which can help students develop a deeper understanding of how various sciences contribute to solving environmental problems. (4) Both teachers emphasize the importance of developing practical skills, such as field skills and experiments, which can be useful for students in understanding and addressing environmental issues in the real world. Overall, both Teacher 1 and Teacher 2 support the idea that the independent curriculum can enhance biology teaching by focusing on practical, interdisciplinary, and environmentally relevant experiences.

3.2 Weaknesses

Weaknesses are conditions or anything that represents a weakness or deficiency within an organization (Puyt et al., 2023). Essentially, weaknesses are a normal condition for an organization, but what matters most is how the institution can address these weaknesses so that they do not become hindrances to the organization (Puyt et al., 2023). The weaknesses referred to in this context are weaknesses related to the implementation of biology education and the prospects for the development of medicinal plant materials in schools.

Based on the observations regarding the weaknesses of implementing biology education at the high school level in Karanganyar, it was found that the schools under observation revealed a weakness in the absence of a medicinal plant garden that could serve as an authentic learning source for students in the context of biology education. The absence of a medicinal plant garden in these schools may limit students' potential to gain richer and more authentic learning experiences in the subject of biology. In biology education, understanding medicinal plants is crucial.

Medicinal plants play a significant role in the field of biology, including the study of plant morphology, photosynthesis processes, plant reproduction, and the chemical components in plants that have health benefits. Unfortunately, we did not find a sufficiently large or diverse medicinal plant garden within or around the school environment. Yet, a medicinal plant garden can be a valuable source of authentic learning for students.

The presence of a medicinal plant garden allows students to observe medicinal plants directly, learn about the morphology and unique characteristics of each plant (Nanjala et al., 2022). A medicinal plant garden can also serve as a means to understand ecosystems and the relationships among organisms (Pramushinta & Ajiningrum, 2017). Students can study how medicinal plants

interact with pollinating insects, soil microbes, and other organisms (Munadi, 2017). They can gain an understanding of the benefits of medicinal plants in traditional and modern medicine (Ervina & Mulyono, 2019). Students can also learn about the process of extracting active compounds from medicinal plants and their use in medicines. A medicinal plant garden also provides opportunities for learning about environmental conservation and the importance of preserving the diversity of medicinal plants (Wijayakusuma, 1999).

Figure 1. Results of Document Analysis of Senior High School in Biology Material

Source: (Puspaningsih et al., 2021)

In Figure 1, the observation findings align with the results of the document analysis used in teaching biology. Examples of documents used in the learning process are presented in Figure 1. Through the analysis of documents in the implementation of biology teaching that we examined, we found that the material on medicinal plants is taught briefly and is often only mentioned in the context of biodiversity. The material on medicinal plants seems to receive insufficient attention in the curriculum or existing lesson plans. Other findings from the document analysis include: (1) Material on medicinal plants is taught briefly, often as a small part of the discussion on biodiversity. (2) This brief material tends not to provide sufficient detail or context for students to understand the importance of medicinal plants in the field of biology and daily life. Students may lack adequate understanding of the processes of extracting active compounds from medicinal plants, the ecological relationships of medicinal plants with the environment, or the medical applications of medicinal plants. (3) The analysis results also indicate that there are no practical activities related to medicinal plants. Students may not have the opportunity to observe medicinal plants directly or engage in experiments related to medicinal plants, which could help enhance their understanding. (4) Material on medicinal plants tends to be placed within the broader context of biodiversity in general. This means that students may not see a deeper connection between medicinal plants and other biological concepts such as plant reproduction, photosynthesis, or evolution.

The results of the document analysis of the learning materials indicate that the content related to medicinal plants is often presented briefly and lacks depth. This finding is consistent with previous research, which identified one of the main reasons for the brief coverage of medicinal plant content as the time constraints within the curriculum (Sakir & Kim, 2020). High school curricula are often quite packed, and teachers must cover many topics in a limited time. Therefore, the medicinal plant material is frequently overlooked or condensed to make room for other topics considered more crucial.

The research results (Botstein & Bialek, 2004) also highlight that a lack of resources and relevant teaching materials for medicinal plant content can be a barrier to in-depth instruction. Teachers may not have access to the necessary medicinal plants or equipment needed to teach this

material effectively. Additionally, the research findings (O'Neil et al., 2020) note the lack of practical experiences in learning about medicinal plants. Students may not have opportunities to observe medicinal plants directly or engage in experiments that could help them understand concepts related to medicinal plants (Carrió et al., 2016).

The research findings underscore the importance of reevaluating the teaching approach for medicinal plant content at the high school level. There is a need to better integrate medicinal plant material into the curriculum, allocate more time for in-depth understanding, and create relevant practical experiences for students. In this way, students can develop a stronger understanding of medicinal plants and their relationship to the field of biology as a whole.

3.3 Opportunities

Opportunities refer to external environmental conditions that are favorable and can even be a weapon for an organization if utilized, potentially becoming an advantage in advancing an organization or educational institution (Puyt et al., 2023). In the context of this study, opportunities pertain to opportunities related to the implementation of biology education and the prospects for developing medicinal plant materials in schools.

The results of interviews with Biology teachers (BT3 & BT4) regarding opportunities state that:

"*Integrating local ethnobotanical content from3.3 Karanganyar can help students understand the local culture and its relationship with the environment. This can enhance their pride in their cultural heritage. Students will have the opportunity to learn more about the plants that grow in the Karanganyar region, including their traditional uses and their significance in the local ecology and culture.*" (BT3)

"*Collaboration with B2P2TOOT (Center for Medicinal Plant Research and Development) provides schools with access to resources and experts in the field of medicinal and aromatic plants. This can enrich teaching and learning in the biology subject, especially those related to ethnobotany and biodiversity. Schools can organize field trips and visits to B2P2TO2T Tawangmangu. Students have the opportunity to see medicinal and aromatic plants up close, learn about their benefits, and understand their vital role in the ecosystem.*" (BT4)

Both of these teachers' statements indicate that integrating ethnobotany, local knowledge, and collaborating with external research institutions can enrich teaching and learning in the field of biology. These statements align with the research findings (Huang & Bu, 2023) that collaboration with external research institutions can help students better understand their local culture and enhance their understanding of biodiversity, as well as the role of plants in the local ecology and culture.

The key takeaways from both teachers' statements can be summarized as follows: (1) both teachers emphasize the importance of integrating local cultural aspects and environmental knowledge into biology education, and (2) both teachers highlight the significance of field experiences in learning. Visits to B2P2TO2T Tawangmangu and field activities can enrich students' experiences and help them connect theoretical concepts with the real world.

Previous research findings have highlighted the importance of integrating local cultural aspects and environmental knowledge into biology education (Thomas et al., 2014), as well as the significance of field experiences or field trips in learning (Luo & Jiang, 2023). Previous research has emphasized efforts to help students gain a more holistic understanding of medicinal plants. More effective biology education should encompass an understanding of how humans interact with the natural environment (Cardoso-Andrade et al., 2022), as well as how local culture and traditional knowledge influence our understanding and utilization of medicinal plants (Franco-Moraes et al., 2021). Through the integration of cultural aspects, environmental knowledge, and field experiences, students can develop a more holistic understanding of medicinal plants. Students can also perceive medicinal plants as part of a larger ecosystem, within the context of local culture, and with an understanding of their benefits to health and society.

Currently, B2P2TO2T has undergone a transformation into the Functional Unit for Traditional Health Services in Tawangmangu (UPF Yankestrad Tawangmangu), which is part of the Dr. Sardjito General Hospital. Now, UPF serves a new role as a healthcare facility, with expertise

in medicinal plants and traditional medicine (Sardjito, 2023). The main task of UPF Yankestrad Tawangmangu is closely related to the vision of Dr. Sardjito General Hospital, which aims to be a culturally superior hospital in service, education, and research (Sardjito, 2023).

3.4 Threats

Threats refer to external conditions that can disrupt the smooth operation of an organization or company (Puyt et al., 2023). Threats encompass any unwanted occurrences that may arise during the learning process, leading to the failure of learning, the non-realization of biology learning objectives, and the absence of prospects for developing medicinal plant materials in schools.

The results of interviews with Biology teachers (BT5 & BT6) regarding threats indicate that:
"*When members of the school community themselves do not pay enough attention to medicinal plants, the topic of medicinal plants in the biology curriculum may be perceived as unimportant or less relevant. This can reduce motivation to teach or learn about the topic. Biology subjects encompass the study of biodiversity, which is closely related to medicinal plants. Neglecting issues related to medicinal plants can lead to neglect of the importance of preserving biodiversity.*" (BT5)
"*Students who are less aware of medicinal plants tend to have minimal interest and motivation to learn about medicinal plants. They may not see the relevance or urgency of the topic in their daily lives. Lack of awareness can result in students having limited or inaccurate understanding of medicinal plant issues. They may have many misconceptions or stereotypes about medicinal plants.*" (BT6)

Overall, both statements by the teachers emphasize the importance of addressing indifference towards medicinal plants in biology education to motivate students, enhance their understanding of biodiversity, and increase their awareness of relevant environmental issues. The key takeaway from both teacher statements is that attention and awareness of medicinal plants are crucial in biology education. Both teachers and students need to recognize the connection between medicinal plants, biodiversity, and their roles within the ecosystem. The lack of awareness about medicinal plants also underscores the significance of broader environmental education, which can help students understand their roles in preserving the natural environment and biodiversity.

The results of previous research indicate that indifference towards medicinal plants can reduce students' motivation in biology education (Hossain et al., 2021; Kayani et al., 2014; Linger, 2017). However, when the material on medicinal plants is taught in an engaging, relevant, and practical manner, students tend to be more motivated to learn (Guven et al., 2019). Students see the importance of this topic in their daily lives, which stimulates interest and active participation in learning.

Medicinal plants are a crucial part of biodiversity, and as students begin to understand the roles and diversity of medicinal plants in ecosystems (Jantan, 1998), they also gain a deeper understanding of biodiversity as a whole (Linger, 2017). Learning about medicinal plants also allows students to become more aware of relevant environmental issues. They learn how excessive use or unsustainable harvesting of medicinal plants can have negative impacts on ecosystems and the balance of nature. Learning about medicinal plants also helps students connect biological science with their everyday lives.

Previous research underscores the importance of a relevant, practical, and engaging approach to biology education. By addressing initial indifference towards medicinal plants, educators can motivate students, enhance their understanding of biodiversity, and help them become more aware of pressing environmental issues. Therefore, a relevant, practical, and engaging approach to biology education can make a positive contribution to environmental education and provide a more holistic understanding of humanity's role in nature.

4. CONCLUSION

An evaluation study of the implementation of biology education that integrates medicinal plant materials in an effort to harness local potential is a crucial step in understanding the impact

and challenges of this approach in an educational context. Through SWOT analysis, the following conclusions can be drawn: Strengths: (1) Integration of medicinal plant materials aligns with the goals of the biology curriculum. (2) Biology teachers possess the competence and experience to support the implementation of medicinal plant materials. (3) Student interest and engagement in biology learning have increased. Weaknesses: (1) Limited resources such as textbooks and laboratory equipment. (2) Resistance from biology teachers towards additional materials. (3) Integration of medicinal plant materials adds to the density of the curriculum. Opportunities: (1) Integration of medicinal plant materials can enhance students' understanding of the relationship between medicinal plants, biodiversity, and the local environment. (2) Engagement with the local community can be enhanced in the learning process. (3) Development of specialized educational resources on medicinal plants can enrich the learning experience. Threats: (1) Cultural differences or societal perspectives can pose a threat to the integration of medicinal plant materials. (2) Time constraints within the biology curriculum could be a threat. (3) Evaluating students' understanding of medicinal plant materials may be challenging. Further research can focus on the development of more specialized educational resources on medicinal plant materials, including modules, textbooks, and educational software that can be utilized by both teachers and students. Additional studies can also explore effective strategies for involving the local community in learning about medicinal plants, possibly through collaboration with local experts or field visits to the local areas.

Ethical approval

Not Applicable

Informed consent statement

Not applicable.

Authors' contributions

Not applicable.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

The data presented in this study are available on request from the corresponding author due to privacy reasons.

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Notes on Contributors

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