

THE PENTAHHELIX MODEL: STRENGTHENING INNOVATION POTENTIAL AND FOSTERING SCIENCE AND EDUCATION INTEGRATION

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Abstract. The Pentahelix model is a holistic and collaborative approach aimed at increasing the potential for innovation and optimizing the integration of science and education. This model consists of five main elements: A(Academy) - B(Business) - C(Community) - G(Government) - M(Media). This study addresses the issue of program failures in both government and private sectors due to the suboptimal role of these five factors. The purpose of the study is to investigate the impact of implementing the model on increasing the potential for innovation and promoting the integration of science and education. Additionally, the effectiveness of the model in supporting cross-functional collaboration is evaluated, the role of each stakeholder is analyzed, and factors influencing successful implementation are identified. Research methods include a detailed literature review, case studies on the implementation of the Pentahelix model in different global contexts, and qualitative data analysis. Research results show that close collaboration among the five elements is an ideal model for building an innovation ecosystem and effectively integrating science, education, and practical needs. The implementation of this model shows that government, industry and academia are having a positive impact on creativity, research and development. However, challenges such as political differences and conflicts of interest remain obstacles. The synergies and interactions between Pentahelix stakeholders contribute to building an innovation ecosystem that supports creativity, research and development. By exploring successful examples and best practices, this study highlights the flexibility and effectiveness of models that foster cross-functional collaboration. The study's conclusions highlight the importance of involving stakeholders and overcoming new barriers. The Pentahelix model therefore, serves as an effective foundation for the development of an inclusive and sustainable innovation ecosystem. This study contributes to a practical understanding of the implementation of this model to promote innovation and science integration in a changing global context.

Keywords: *Pentahelix; Collaboration; Research; Innovation*

A. INTRODUCTION

There are two stakeholders who are considered to be government partners in playing a role in national and state life, namely academics and the business sector. These three which we know as the triple helix. Academic component has a role in conducting research or studies. This research is aimed at dissecting all phenomena that occur to be studied using scientific methods to produce useful conclusions. Business sector component plays a role in reviving economic activities through production-distribution-consumption activities. These economic activities

have the aim of meeting community needs through the goods and services produced. The existence of economic activities also provides opportunities for community members to be actively involved in them. Community/society members are human resources as an actor who combines all factors of production. So there is a broader role than just seeking financial gain. Meanwhile, the government has a role as a facilitator to enable the smooth running of community activities as a whole, including the other two components.

This role is carried out by formulating crucial public policies such as: public security, public services, taxation and the provision of basic infrastructure such as bridge and road networks, irrigation, energy and telecommunications. This role can only be carried out by the government because the main purpose of the government's existence is not to seek profits like the business sector, but to ensure the existence of a country and the smooth running of life for all citizens living in it. If the business sector were entrusted with this role, it would be impossible because we cannot ask people crossing the bridge to pay, for example. Likewise with academics. Their intellectual capabilities will be effective in relation to conceptual exploration, how the results of the research conducted can be adopted by the government as raw material for policy so that the public policies designed are in accordance with scientific principles. Or if it is related to the business sector, it is how to optimize goods/services related to production mechanisms, managing business human resources or improving marketing strategies.

In its development, more or less since 2018, the triple helix concept has developed into a pentahelix or the addition of two other components of society to make it became five (Amin, 2020). First is mass media. Mass media, or what we usually know as press, is a societal component that has a role in summarizing and disseminating information regarding all events that occur in society. As humans, it is certainly impossible for us to be in more than one place at one time, however, it is very possible that events that occur in other places will also have an impact on us. Take for example when a disease outbreak occurs in another place. When this information is disseminated through the mass media and reaches us, we, as members of society or as part of government authorities in our region should have anticipated steps to prevent and control the outbreak to minimize the potential negative impact. Mass media has a role in shaping the perceptions of its viewer so that they can behave and act based on the information disseminated. This includes academic innovation or scientific breakthroughs being published, which will make us feel proud and amazed because there is hope that this will have a positive impact on humanity. And what we also see every day are advertisements circulating in all information channels, both offline and online, which persuade people to buy and use the products advertised. The distribution of information that reaches us will be able to change perception, rationality and could possibly save our lives from possible dangers. Second is community, which is a combination or group of community members who have a certain social forum, whether in the form of neighborhood associations, ethnic-religious-racial groups, professional associations, political organizations or other groups. The community is the citizens themselves, but in different segmentation so that programs or activities aimed at the community can run efficiently rather than just implementing it as a whole. Take the example of a local road in a certain settlement area, of course it is (mostly) only aimed for local housing residents or other people who visit there. Or the independent campus policy which is aimed only for college/university students and not for high school students, for example.

Conceptually, connectivity chart between each pentahelix element can be depicted as follows (Vani et al., 2020):

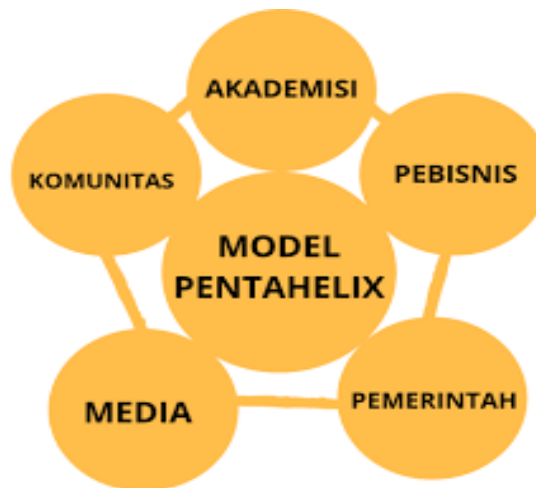


Figure 1 Pentahelix Model

From this chart, it can be seen that everything is connected. The five elements of pentahelix are part of a large group of nations that have related roles. The linkages and impacts will be explained further in the next section.

Everyone has the same perception that education is a strategic effort in building the quality of human resources as a factor of production in the economic system. Human resources are a production factor besides raw materials, capital and technology/equipment with strategic value. The strategic value of human resources is obtained from their ability to combine the three other production factors so that they can be effective in producing the desired goods/services. Without human resources, quality raw materials, a lot of capital or even sophisticated equipment cannot be used to produce goods/services. We also have to understand that to be able to combine these three production factors, human resources must first have good quality. This is important because if, say, human resources are not qualified they will not be able to manage capital effectively and efficiently. There is a possibility that this capital will be used in vain or for personal interests only. Likewise with technology, which has the potential to be used for useless things instead of productive activities if controlled by human resources that do not have good quality.

Improving the quality of human resources is obtained through the education process. Through this process, a knowledge transfer process will occur between teachers/lecturers and students. This transfer of knowledge will equip students with a conceptual understanding and practical capabilities according to their respective scientific disciplines so that after they complete their education, students will be able to have academic abilities that can be applied in their professional environment or in society. The educational process, especially the higher education process, which is taken after completing the primary and secondary education stages, is generally the last level that a young person takes before playing a role in society because it is at this stage that the process of scientific specialization is carried out. It is impossible for us to be experts in all fields because basically, science is very complex and always develops with the times, so, of course, we have to choose which field of science suits our interests and talents. complex and always develops with the times, so, of course, we have to choose which field of science suits our interests and talents. The primary and secondary education process, ideally, equips students with environmental understanding, tolerance, cooperation and

direction of interests and talents so that they will be more mature at the higher education level.

For higher education institutions, with their very noble role, become independent entities? Of course, it is not like that. Educational institutions, including higher education, are just one of the actors in society that have a role in maintaining the quality of human civilization. This concept cannot be separated from the development of the democratic process, namely a global understanding process teaches the entire nation that in carrying out the government and development process, each group of citizens has their own role which must be accommodated by the state. So this negates the authoritarian concept which was taught by many ancient philosophers and applied by several countries in the world until the 20th century. The concept of authoritarian government teaches that the role of government can only be carried out by one or a few groups, other citizens are only allowed to obey and follow. This is very incompatible with modernization which teaches openness because authoritarian practices actually retard development progress because only a small number of people in a country and do not allow for optimal distribution of economic prosperity to all levels of society.

B. METHODS

The material used for this paper comes from literature obtained mostly through online sources. These literatures contain mainly the concept of pentahelix itself and exposure of several research and facts that show about application of pentahelix in public life and examples when there are no pentahelix applied properly. The sources of material obtained through scientific journals, government publications, mass media news and teaching materials. The method used is a literature study so it relies on secondary data.

The literature review method, or often referred to as literature review, is a research approach related to the collection and analysis of information from written sources or literature relevant to the research topic. This approach does not involve primary data collection, but focuses on synthesis and understanding of existing research and ideas. Literature review is information that is relevant to research problems, the data can be obtained from various literature information such as journals, scientific books, research reports, scientific essays, theses and accompanied by written sources both printed and electronic. This information will be used as a basis for reference or support in overcoming research problems (Harris, 2019).

A literature review is a survey of scholarly sources that provides an overview of a particular topic. Literature reviews are a collection of the most relevant and significant publications regarding that topic in order to provide a comprehensive look at what has been said on the topic and by whom. The basic components of a literature review include description of the publication, a summary of the publication's main points, discussion of gaps in research and an evaluation of the publication's contribution to the topic. Literature review papers (LRPs) are often very helpful for researchers, as thereader gets an up-to-date and well-structured overview of the literature in aspecific area, and the review adds value (Wee & Banister, 2016). Literature reviews are a critical part of scientific research (Kraus et al., 2022).

This literature study process is divided into four stages:

1. Searching for materials: explore relevant literature sources
2. Editing: re-examination of the data obtained, especially in terms of completeness, clarity of meaning and harmony of meaning between one another;
3. Organizing: organizing the data obtained with the required framework;

4. Finding: conducting further analysis of the results of organizing data using predetermined rules, theories and methods so that conclusions are found which are the results of answers to the formulation of the problem).

The criteria for literature chosen as a reference in this writing are contains a discussion of the concept of pentahelix collaboration, case in point of successful development project involving pentahelix elements. Examples of cases of failure or phenomena that bring losses in society due to the lack of application of pentahelix. The search process uses search engine applications by using relevant keywords. There are dozens of articles used to create this paper which are divided into nine journals, two lecture materials and four online news references. The content contained in each of these references is also not arbitrary. For example, for the issue of pentahelix collaboration, the substance discussed must be the dominant material in the reference used and not just as an opening. Likewise, related to the issue of case examples, the references used do discuss the issue in full such as news about Yogyakarta International Airport airport operations or news about waste problems in Yogyakarta.

C. RESULT & DISCUSSION

The connection between pentahelix elements is very necessary in the modern era. As previously explained, the five elements of the pentahelix have their own unique roles which enable connection and collaboration between them. As we all know, Indonesia is currently still in developing country status, and as a developing country, of course the national vision is to upgrade to become a developed country. We certainly want Indonesia to be able to have indicators as generally found in developed countries, namely high per capita income, low levels of unemployment due to high employment opportunities, low infant and maternal mortality rates and good quality of education. Progress in developed countries is achieved through a consistent development process in each development sector. In mendeley.com, there are 362 journals, 26 conference proceedings, 8 reports, 5 generic, 4 book sections, 2 books and 2 web pages discussing the pentahelix as a reference. The pentahelix model is used in the fields of tourism, environment, entrepreneurship, covid handling, public services, economy, disaster management, community development and even terrorism deradicalization programs.

Indonesia in the 2019-2024 period has priorities to accelerate infrastructure development which includes industrial, tourism and agricultural infrastructure. Next is to facilitate investment and bureaucratic reform as well as human resource development. These sectors are priorities that are being implemented in order to fulfill national development, and we also hope that after the process of succession government through the general election in 2024, these priorities can still be maintained in continuity (Menpan, 2023).

In the framework of this development, as explained in the previous chapter, to carry out this process requires the active role of all elements of the citizenry which are divided into five pentahelix components according to their respective professional capabilities. This active role cannot simply be denied because modern government requires a democratization process. Government is not a process that is only run by the executive or the bureaucracy itself, like has practiced authoritarian government in the 20th century. The government process, including development, must accommodate all elements. in order to realize government transparency, and indeed, this is also what countries that are already done by developed countries. For Indonesia, even though we are still at the developing country stage, in general, what must be done is consistent application of the pentahelix. We no longer want to repeat the history of the New Order regime which was dominated by the role of the executive alone.

In principle, all development sectors can become objects of the pentahelix. We can take the example of the tourism sector. This sector is generally a favorite in national development because it can stimulate fast circulation of money through increased tourist visits and indeed, Indonesia has great tourism potential through the potential for diverse natural and cultural tourism (Raditya, 2021). The Covid-19 pandemic has hampered the progress of this sector due to policies to limit people's travel to overcome the spread of the coronavirus, but with the situation starting to recover, this sector can be accelerated again. We understand that generally, communities take a technical role in managing tourist attractions. This role is usually carried out by handling daily management, providing local products such as culinary delights and souvenirs and various other services. The government's role is to provide the basic infrastructure needed to support the accessibility and mobility of people to and from these tourist attractions, such as road networks and easy telecommunications networks. Telecommunication here means, don't let a tourist attraction become so remote or isolated that it cannot reach cellular signals, unless it is a tourist attraction with a special interest/segment. This ease of telecommunications not only speeds up evacuation and emergency services purposes due to disaster, but also makes it easier to access online transportation services which are currently able to accompany regular transportation service modes.

The role of the business and academic sectors is to provide assistance and facilitation as well as supervision to optimize the potential of existing tourist attractions. The business sector can facilitate the development of tourism support services including business management training so that the business administration and financial processes of tourism actors can be well-managed and transparently, including the implementation of electronic transactions at tourist attractions. In fact, there are also tourist attractions that are managed by corporations, such as the Prambanan and Ratu Boko Temple areas in the Special Region of Yogyakarta which are managed by PT. Taman Wisata Candi. Likewise, academics can play a role in making tourism potential the subject and object of research. What kind of potencies is still possible to explore, what is the best mechanism for managing rubbish or waste at tourist attractions, how to increase the level of satisfaction of visitors to tourist attractions or facilitating students to carry out research and internships at tourist attractions. The media also plays an important role in creating positive news to increase the interest of tourists both from within and outside the country. News has a function as an advertisement for the public to allocate the time and money they have to visit the tourist attraction. In the current era, the reporting function of mass media has been helped by the massive development of social media. Everyone can be a "reporter" by posting on their own social media accounts and spreading their thoughts for their followers. Pentahelix has been carried out in previous studies as a problem-solving found that Pentahelix has five actors namely Government, Private, Society, Media, and Academics (Bagdja & Nohong, 2023).

Another fact in one of the articles with the title of a policy model for the development of the marine tourism industry through inter-regional cooperation policies in Lampung Province, the subtitle of the 3rd year of the Pentahelix Model Collaboration in Tourism Industry Development Policy in Pesawaran Regency. The results stated that the suboptimal development of tourism and the tourism industry was due to the lack of collaboration and synergy of pentahelix components (Duadji et al., 2021). Di lain studi The Study of Sigapiton Tourism Village Development Through the Pentahelix Model, Ajibata District, Toba Regency shows that not every helix did their roles and contributions as expected. This leads to the stagnation of the development of Sigapiton Tourism Village (Tondang, 2021).

Halal tourism development also one important example of pentahelixi. Islamic science contributed to promote inclusive and sustainable economic growth, full and productive employment and decent work for all. The tourism sector has emerged as a pivotal contributor to Indonesia's economic growth. Within this industry, Halal tourism holds significant promise as an added value. Among the stakeholders in the Pentahelix system of the Halal tourism sector, Pesantren plays a pivotal role in various facets. It is instrumental in identifying Halal tourism destinations, heightening public awareness in food preparation, selecting travel services and themes, and establishing payment protocols for travel services. Furthermore, Pesantren actively engages in the educational process pertaining to Islamic business, enhancing the broader ecosystem of Halal tourism in Indonesia (QOMARO, 2019).

Another example is in public transportation services. The government's role is very clear here, namely providing basic facilities and infrastructure including road networks, traffic control signs and lights, bus shelters, bus terminals and what also sometimes missed from our attention are non-physical aspects. Non-physical aspect here is public policy related to the sector concerned. If it is about public transportation, it concerns route licensing, facilitating various cooperation to support transportation services and guaranteeing security for passengers so that they feel safe and comfortable using public transportation modes. The role of the business sector is as an operator of public transportation itself, whether offline or using online platforms. Despite Indonesia's national regulations which are still ambiguous regarding online transportation services using two-wheeled vehicles or motorcycles, the fact remains that this mode can be accessed by the public and transactions between passengers and operators, meaning it is a valid public transportation service.

The role of community as the passengers or consumer or any kind of stakeholders who give contributions for supporting public transportation services. There are transportation triangles which connect stakeholders: Elements of mass media and academics can actually be included as part of society, remembering that even though the format is a triangle, the role of these two stakeholders cannot be ignored. Academics have various roles based on scientific discipline to carry out analysis of studies for optimal attraction and generation potential for public transport service routes, analysis of financing and potential investment in transport as well as evaluating load factors for public transport routes. Academics can also play a role in helping to explore people's aspirations regarding the need for public transport services in their area through a series of surveys whose results, if affirmative with the policy plan, can become social and political legitimacy for the executive to ensure the policies that will be made, and if they are negative, then a new strategy needs to be designed to adapt to community needs. The mass media is tasked with gathering public opinion so that it can support government policy plans in the context of developing public transportation services (Nugraha, 2021).

Pentahelix strategy is also useful in certain conditions, especially if they are found to require a special and intensive approach. For example, a development activity program that must synergize with local wisdom. Bureaucratic agencies usually have limited authority and work methods that tend to be formal, so they are not flexible when they have to deal with local community groups who usually use informal work methods (Nugraha, 2014). This gap can be filled by academics. Research works require primary data obtained by taking a direct and personal approach to community groups. The data or information obtained will become raw material for government policy and on the other hand, also help the business sector in identifying regional economic potential. What happens if the pentahelix doesn't work? It could hinder development progress. This is because there is no adequate exchange of information. It is possible that a development program still running but missed the ideal target, thereby wasting

the public resources that have been expended. Pentahelix physically still exists because each institution in these sectors still exists but there is minimal collaboration. An example is Giwangan Terminal in Yogyakarta which was built in the 2000s and had created conflict between the Yogyakarta City Government and a private developers company (Sis, 2018). The private sector feels disadvantaged by the government because the promised profits failed to be achieved. The existence of Giwangan Terminal does not make the southern Yogyakarta area as economically vibrant as in the north Yogyakarta area, so the circulation of money is not optimal. This is very likely to happen because there is no adequate feasibility study which should be carried out by the government together with academics before formulating public policy.

In the environmental field there are some good practices by optimizing the pentahelix model. The eco-design innovation of waste processing with a digital-based waste bank program with a synergistic pentahelix approach has become an innovation at the grassroots level, especially in Sukoharjo. Waste banks in the Sukoharjo area need to be further involved in this waste management, so that the effectiveness of its management increases and the economic benefits taken can be maximized (Karnawijaya et al., 2022). Another study, pentahelix movement through ecopreneurship-based waste management formed a Pentahelix movement by collaborating with the Kendal Regency Government Environment Office, Bank Sampah Induk (BSI) Kendal, Kendal Family Welfare Development Team (PKK), Kendal Industrial Estate (KIK) and Kendal Regency National Narcotics Agency (BNN). The results of the service showed that the socialization and training of eco-enzyme were able to foster and increase public awareness by 80% with 65% from parents and the rest from millennials. This means that this socialization is quite effective and can really impact the surrounding community towards waste reduction (Muyassarrah et al., 2022).

Another example is the complexity of handling waste in the urban area of Yogyakarta in mid-2023. The Yogyakarta Special Region Government suddenly closed the final waste storage site in Piyungan, Bantul. They said that the capacity of Piyungan waste terminal was no longer feasible but was not balanced with the preparation of replacement land and an adequate ecosystem policy so it must be acknowledged that public unrest has arisen because they have not been sufficiently educated about sorting and processing waste independently. There are still many people who don't even have independent trash cans. Yogyakarta city ring road has become an accidental "trash can", to mock the name of the official ring road. This waste management problem should be better if we apply the pentahelix principle consistently, namely before closing the Piyungan waste terminal, it should be preceded with preparing replacement land in each district and/or city area and start implementing the waste bank movement at the sub-district/village level. The waste bank movement means that the community or society will also play an active role in sorting waste so that it will reduce the volume of waste that is thrown away. To be able to bridge this empowerment and waste processing training, this is where the role of academic elements is to teach the community with appropriate work methods and the role of the business sector is to absorb products produced from community waste banks so that the local economy also develops. Let's take the example of shopping bag products made from coffee sachets or washing soap sachets. Have we ever seen these goods sold generally in supermarkets or convenience stores other than the producer's own neighborhood level (Eka Arifa Rusqiyati, 2022)?



Figure 2 Terminal Giwangan

Examples of cases of public services that are not optimal if the pentahelix does not work well.

Sources :

<https://jogja.antaranews.com/berita/552457/tpa-piyungan-ditutup-yogyakarta-hadapi-potensi-darurat-sampah> and <https://jogja.tribunnews.com/2018/02/26/terminal-giwangan-pernah-dinobatkan-sebagai-terminal-terbersih>



Figure 3 Pentahelix Application Failure Model

So are there any positive examples? We can refer to Yogyakarta International Airport (YIA) in Kulon Progo Yogyakarta. This airport, which is also one of the national strategic projects, is quite smooth in its implementation. The study regarding adequate airport layout plus the economic impact is quite complete. The process of replacing compensation for land and property belonging to affected residents was also relatively minimal in terms of turmoil because in the end, all of them were willing to relocate and start their new life in a new place even though it was still in the Kulon Progo area and it took almost two years to carry out socialization so that residents were willing to give their land for the airport project. Plus, the role of mass media is quite massive considering recently, YIA is the largest airport in southern Java and Yogyakarta's position as the second main destination in Indonesia after Bali. The physical construction process can be said to be quite fast, but for social engineering for affected residents which requires special efforts is a pretty good example for the application of pentahelix (Admintemon, 2023).



YIA airport as an example of pentahelix application. Source : <https://temon.kulonprogokab.go.id/detail/510/6-keunggulan-bandara-yia-dikapanewon-temon-tahan-gempa-dan->

Figure 4 Successful Application of the Pentahelix Model

We still have homework to maintain consistent application of pentahelix. It is true that these five pillars exist, but we have to criticize whether their implementation has been effective or not for social and academic legitimacy. We can say that the majority of existing public policies are often just a chase-for-show orientation. Just for publishing quickly, but its sustainability is still not guaranteed. This is not good because it does not provide certainty. Science has a common issue with policy and business processes in terms of sustainability. Business that is not sustainable means wasting money and policies that are not sustainable also mean wasting budgets and other public resources. A research process that is not continuous or sustainable also means wasting intellectual potential. We are not talking about academic matters in classes but beyond that, how the research process can have a significant impact on society in real terms and not just theories in the ivory tower. In simple terms, we can conclude that the potential for innovation and increasing the scientific perspective of science can be wasted when the pentahelix cannot be applied effectively.

The ideal hope for scientific performance is the impact arising from fresh ideas, innovations and breakthroughs that are born from academic process and research laboratories, but we must also understand that the academic sector as the perpetrator does not have the authority to carry out direct execution in the community like business and government sectors and are also not authorized to take on the role of the mass media sector except to provide positive news material. Therefore, reflecting on the existing cases, it is appropriate for each element to be able to collaborate with each other. Maybe it will be difficult for us if we only rely on the government. Each element is able to take an initial initiative based on a particular issue first as a starting point for cooperation.

Pentahelix collaboration is also advancing innovation potential and shaping science and education dynamics (Korostyshevskaya et al., 2019). Saint-Petersburg national research university of informational technology, mechanics and optics (ITMO University) as one of the leading entrepreneurial universities in Russia. ITMO uses this model in developing the concept of entrepreneurial universities is becoming more important nowadays in the condition of unstable economic development, digital transformation of the economy and other challenges the World economy faces. It can be explained by the fact that such universities substantially contribute to competitiveness of national innovation systems by encouraging and supporting commercialization of technological developments (CTD). This is interesting because this pentahelix model can optimize concept development substantially.

The application of the pentahelix concept can also be applied to vocational schools, where vocational education institutions should play their best role, in idealistic norm, for

preparing their graduates for the world of work (Rosie Oktavia Puspita Rini et al., 2023). Education science hopefully could increase the capacity of professional teachers, revitalizing professional education with more experts, and educational machinery. Moreover, it can be rebranded through direct research to industry and comparative in more advanced educational institutions both at home and abroad, while adding personality to students. Therefore, it is hoped that vocational education can participate in real efforts to implement government programs aimed at advancing Indonesia by preparing superior human resources. The business sector also has a role in strengthening vocational schools as places for internships, work practice, guest lecturers and, most importantly, absorbing vocational school graduates in their industry.

Therefore, the pentahelix collaboration model is indispensable for the quality of vocational education improvement.



Source :
<https://smkbinapatria1sukoharjo.sch.id/prakerin-praktek-kerja-industri/>

Figure 5 Cooperation between Toyota Nasmoco and SMK Bina Patria 1 Sukoharjo

In the development of Islamic science, this model is also needed. One of the implementations of this model is in the development of zakat management developed by Badan Amil Zakat Nasional (BAZNAS) as a sharia social financial institution offers the latest technology in the process of socialization, service and zakat fundraising. BAZNAS developed Zakatech. The main strategy needed in terms of developing ZakaTech is the ability of human resources (amil zakat) in managing and analyzing data in the era of big data using digital services. The main elements involved in ZakaTech development in Indonesia include the government as a regulator, educational institutions (including universities), and existing industries (pentahelix) (Budi, 2022).

In another study, about Pentahelix Based Entrepreneurship Management At PKBM Asholahiyah (Hoerniasih et al., 2022). The study's results indicate significant benefits for contributors, including improved skills in business capability mapping and enhanced knowledge in business potential mapping, marketing strategies, and business management techniques. The program has practical implications, boosting understanding of the Pentahelix principle, media utilization for marketing, and capital management for MSME development. This Pentahelix-based entrepreneurial approach positively impacts entrepreneurship skills, systematically aligns with local entrepreneurial potential, and enhances marketing and business control techniques.

D. CONCLUSION

Pentahelix is a combination of five elements in the social system, namely A (Academics) - B (Business) - C (Community) - G (Government) - M (Media). Synergy using the pentahelix model strongly supports any social change. In addition, it can optimally increase resources from academic, *business, community, government and media* (ABCGM) elements. This study found that pentahelix model the impact of implementing the model on increasing the potential for innovation and promoting the integration of science and education. Some articles mention the success of the program due to the optimization of the role of the pentahelix. And vice versa failure and less optimal program due to lack of coordination and synergy between pentahelix elements. The Pentahelix model is an ideal model for the development of innovation, research, scientific and technological discoveries and can be applied in various fields of life. In this discussion, the implementation of the pentahelix model in the fields of education, environment, tourism, community empowerment, economy, disaster risk reduction and others are reviewed. Optimization of the role of each element in the pentahelix is indispensable in the integration of scientific and educational development.

The deepening of the role in the pentahelix can be described as follows. Academicians (A) can act as a drafter, because academics can reproduce knowledge, develop theories and make various innovations both products and thoughts. Business (B), in this case business people can act as enablers, so that the ideas of academics can be realized, or realized. Business can present infrastructure, technology, capital, product development, marketing models and others. Furthermore, in the context of social change, community (C) can play a role in accelerators. The expected community certainly has the same frequency in making changes, developing and supporting academics and business. While the government (G) in this case can act as coordinator, regulator and controller. The government must also be bridging between all elements in all activity cycles. The activity cycle in question includes planning, implementation, monitoring, control, promotion, financial allocation, licensing, development and knowledge, public innovation policy, support for innovation networks, and partnerships between the public and private sectors. Finally, the media (M) can play a role in information dissemination, image branding, education and support issues relevant to the role of the other four elements.

Modern governance emphasizes democratization and collaboration as the antithesis of authoritarian government systems that are still commonly found in the world towards the end of the 20th century. The increasingly rapid development of the world and science will not be able to keep up with one country if it only relies on the bureaucratic system because there are other elements that also play their own specific roles. The government is not authorized or competent to carry out profit-making work which is the domain of the business sector. They are not competent to carry out professional research work which is the domain of the academic sector and not fit to monopolize public information which is the domain of the media sector. Also the government is not able and should not monopolize life society because it will give birth to authoritarian government practices.

We can see many examples in real life, what would happen if there was no symbiosis between these elements. They may all exist, but the connectivity between them still needs to be optimized. We can take the example of problems in the management of Giwangan Terminal in Yogyakarta which were problematic in the early 2000s to 2010s due to the "ambition" of the local government which wanted to revive the economy of the southern region of Yogyakarta but without adequate study analysis. Currently (the 2020s decade) perhaps the economic potential has increased, but at that time, of course, it must first start with a thorough study and not just idealistic ambition (which is not necessarily feasible). Then there is the problem of waste

management in the Yogyakarta urban area which should not be this complicated. The lack of policy communication and education for the public to be skilled in managing waste has resulted in waste management emergency status such as in Yogyakarta City and Bantul Regency areas. This is evidence of the lack of role of the academic sector, media sector and business sector.

However, there is one example to be proud of, namely Yogyakarta International Airport (YIA) in Kulon Progo Regency, which is a successful example of pentahelix collaboration. If there is no collaboration, it could lead to conceptual immaturity and the threat of stalling, as happened in the various public private partnership (PPP) projects in the mid-2010s, or major social conflict with the affected people or communities. The main point that we must hold is that pentahelix collaboration will be able to have the opportunity to realize useful innovations if this collaborative perspective can be implemented between all elements. We don't want many innovation breakthroughs to be wasted simply because of a lack of understanding or unwillingness to collaborate. Other things that has tight connection for pentahelix are vocational education. We cannot produce many skilled graduates from vocational education without active contribution from business and community sectors. Halal tourism also one urgent important. We, and even non-moslem countries has been develop halal tourism for attracting moslem tourists so they can travel comfortably without having to worry about halal food. Hence, the roles of community and media are much important and unable to ignored.

In conclusion, the research on the Pentahelix Model underscores its pivotal role in shaping a dynamic and inclusive innovation ecosystem. By integrating the academic, business, community, government, and media elements, the model provides a holistic framework that fosters collaboration, creativity, and sustainable development. The findings highlight the model's effectiveness in enhancing innovation potential and promoting the seamless integration of science and education. The critical role of government policies in creating an enabling environment for innovation cannot be overstated. As evidenced by the research, supportive policies play a key role in encouraging research and development, facilitating collaboration among stakeholders, and ensuring the ethical shaping of innovation initiatives. The involvement of industry through technology transfer, social responsibility, and collaborative research initiatives showcases the tangible contributions businesses can make to the evolving innovation landscape.

Academic institutions, positioned as knowledge hubs, are instrumental in propelling research, education, and skill development. The emphasis on academic-industry partnerships and civil society's active involvement emphasizes the importance of a collective effort in shaping innovation policies ethically and driving meaningful change. Despite the positive impacts observed in the implementation of the Pentahelix Model, challenges persist, including policy differences and conflicting interests. These obstacles necessitate ongoing efforts to enhance stakeholder integration and overcome barriers to create a truly effective innovation ecosystem. The synergy and interaction among Pentahelix stakeholders contribute significantly to the model's success. Successful case studies and best practices from diverse global contexts highlight the adaptability and efficacy of the Pentahelix Model in advancing cross-sectoral collaboration.

In summary, the Pentahelix Model is a solution to answer and solve various problems, emerges as a valuable foundation for developing an innovation ecosystem that is both inclusive and sustainable. This research not only contributes to a theoretical understanding of the model but also provides practical insights for policymakers, researchers, educators, and practitioners seeking to navigate the complexities of innovation and science integration in our ever-evolving global landscape. As we move forward, continued dedication to overcoming challenges and

fostering collaboration among diverse stakeholders will be essential for realizing the full potential of the Pentahelix Model and, in turn, driving positive societal impact through innovation.

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