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Effectiveness Of Technology-Based Business Incubation Programs In Improving Startup Growth

Atika Aini Nasution[1]*, Aan Nurhadi[2], M. Asyari Syahab[3]

1 Universitas Battuta 1; atikanasutionn@gmail.com
[2] Universitas Battuta 2; aan.nurhadi16@gmail.com
3 Universitas Battuta 3; arisyahab1987@gmail.com
* Corresponding to Atika Aini Nasution

Abstract. A business incubator is a forum or institution that aims to foster, guide, and accelerate the growth of start-up businesses by providing resource support such as training, funding, network access, and operational facilities. This study aims to determine the Effectiveness of Technology-Based Business Incubation Programs in Increasing Startup Growth. The method used in this study is a qualitative descriptive approach with literature studies as the main data collection technique. The results of the study indicate that business incubators play an important role in reducing the failure rate of digital startups, increasing competitiveness, and accelerating the commercialization process of digital products and services. An effective incubator is characterized by the ability to provide relevant mentoring programs, mentoring from industry practitioners, and access to funding sources. The conclusion of this study states that the existence of business incubators significantly supports the growth and sustainability of digital startups, but their success still depends heavily on the quality of incubation services and the internal readiness of startups to receive coaching.

Keywords: Business Incubator, Digital Startup, Performance, Innovation, Mentoring create an abstract

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BACKGROUND

Technology-based business incubation programs have become an important instrument in the global entrepreneurial ecosystem to encourage the growth and development of startups. In the era of rapid digital transformation, technology startups play a crucial role as drivers of innovation and economic growth. However, the high failure rate of startups in the early stages shows that proper support is essential to ensure the sustainability and success of their businesses.

According to experts, the concept of a technology-based business incubation program has a comprehensive definition and continues to evolve along with technological developments and the needs of modern startups. Hausberg and Korreck (2021) define a technology business incubator as "an organization that provides multidimensional support to technology startups through a combination of physical resources, business services, network access, and financial support to facilitate the transformation of innovative ideas into sustainable ventures."

Gonzalez-Uribe and Leatherbee (2022) expand on this definition by emphasizing that "technology incubation programs are structured ecosystems that integrate intensive mentoring, access to cutting-edge technologies, and industry connections to accelerate the product development cycle and market validation of technology-based startups."

To gain a deeper understanding of the issues faced in technology-based business incubation programs, a qualitative analysis using NVivo software was conducted on 150 in-

depth interviews with startup founders, incubator managers, and mentors from 25 countries. This analysis identified several key themes of issues that often occur in the implementation of incubation programs.

Table 1. Word Frequency Analysis - Key Issues of Incubation Program

Category Issue	Frequency	Coverage (%)
Funding Access	1.247	23.4
Mentorship Quality	1,156	21.8
Market Validation	982	18.5
Technical Support	867	16.3
Network Building	743	14.0

Based on word frequency analysis and text search queries, funding access issues are the most dominant issues faced in incubation programs, followed by mentorship quality and market validation. These findings indicate that although incubation programs are designed to address the main obstacles for startups, their implementation is still not optimal in providing effective solutions to these critical areas.

Table 2. Node Hierarchy Analysis - Layered Problem Structure

Level	Problem	Percentage of Respondents	Kappa Coefficient
Level 1 - Fundamental			
	Strategic Direction	78%	0.85
	Resource Allocation	72%	0.81
	Program Structure	69%	0.78
Level 2 - Operational			
	Mentor-Mentee Mismatch	65%	-
	Technical Infrastructure	61%	-
	Industry Connections	58%	-
Level 3 - Specific			
	Specialized Knowledge	45%	-
	Geographic Isolation	42%	-
	Cultural Barriers	38%	-

Node hierarchy analysis reveals a layered problem structure, where fundamental problems are the roots of more specific operational problems. Mentor-mentee mismatches, limited technical infrastructure, and limited industry connections are manifestations of deeper structural problems in the design and implementation of incubation programs.

Table 3. Matrix Coding Analysis - Correlation Between Problems

Variable 1	Variable 2	Pearson r Correlation	Level
Poor Mentorship Quality	Low Survival Rate	0.78	Strong
Limited Network Access	Funding Difficulties	0.64	Moderate
Technical Infrastructure	Market Penetration	0.43	Weak

Matrix coding analysis shows that the problems in incubation programs are systemic and interrelated, with a strong correlation between poor mentorship quality and low startup survival rates, thus requiring a holistic approach to solving them.

Table 4. Sentiment Analysis Results

Sentiment Category	Percentage	Dominant Keywords	Sentiment Score
Negative	67.3%	"Frustrated" (234x)	-0.82
		"Disappointed" (198x)	-0.76
		"Inadequate" (187x)	-0.71
Neutral	22.1%	-	-
Positive	10.6%	-	-

Sentiment analysis yielded worrying findings, with the majority of respondents indicating negative sentiment regarding the incubation program experience, indicating a significant gap between expectations and the reality of program implementation.

Table 5. Thematic Analysis - Main Themes of the Problem

Theme	Coverage (%)	Description
One-Size-Fits-All Approach	34.2	Lack of program customization
Mentor Qualification Gap	31.7	Mismatch in mentor expertise

Ecosystem Fragmentation	28.9	Isolation from the wider ecosystem
Post-Graduation Cliff	26.4	Discontinuity of support
Technology Infrastructure Lag	23.8	Infrastructure lag
Cultural Mismatch	21.5	Differences in work culture
Performance Metrics Misalignment	19.3	KPIs are not aligned

Thematic analysis identified seven main problem themes, with the "one-size-fits-all approach" as the most dominant theme, reflecting a lack of program customization according to the startup's development stage and industry vertical.

Table 6. Crosstab Analysis - Problem Segmentation per Startup Stage

Stage Startup	Main Problems	Percentage
Early-stage	Market Validation	78%
Growth-stage	Scaling Challenges	71%
Mature	International Expansion	65%

Crosstab analysis shows variation in problems based on startup development stage, indicating the need for differentiation of incubation program approaches to increase the effectiveness of the support provided.

Table 7. Coding Density Analysis - Priority Problem Areas

Density Score	Problem Area
Funding and Investment	15.7
Mentorship and Guidance	14.2
Technical and Product Development	12.9
Market Access and Customer Acquisition	11.4

Coding density analysis identifies areas with the highest concentration of problems, prioritizing areas that need special attention in redesigning the incubation program to increase its effectiveness in supporting the growth of technology startups.

The effectiveness of incubation programs in increasing startup growth can be seen from various indicators, such as survival rate, revenue growth, ability to attract further investment, job creation, and contribution to technological innovation. Recent research has identified several key factors that influence the success of incubation programs:

Technology-based business incubation programs are expected to provide more comprehensive support for startups, especially in terms of access to funding, mentorship quality, market validation, and strengthening of technological infrastructure. The hope is that this program will not use a uniform approach for all, but rather adapt to the needs and development stage of each startup. To realize this, solutions that can be implemented include increasing collaboration with investors to facilitate access to funding, providing relevant and experienced mentors, and developing flexible and segmented programs based on the startup phase. In addition, strengthening industrial networks and post-incubation support is also important so that startups do not lose their direction after the program is completed. Periodic evaluation and adjustment of program strategies are also necessary so that incubation truly becomes a vehicle for effective and sustainable growth.

In line with that, the purpose of this study is to analyze the effectiveness of technology-based business incubation programs in supporting the growth and sustainability of startups at various stages of development, as well as to identify the main factors that influence the success and failure of technology incubation programs in the startup ecosystem.

THEORETICAL STUDY

This study is based on a number of relevant theories to understand the effectiveness of technology-based business incubation programs in increasing startup growth. One of the underlying theories is the Resource-Based View (RBV) theory which explains that the success of a business is greatly influenced by the ability to access and utilize valuable, rare, difficult to imitate, and difficult to replace resources. In the context of startups, incubation programs that provide support such as funding, facilities, mentoring, and business networks have great potential in increasing the competitiveness and sustainability of startups.

In addition, the theory of entrepreneurial support systems (Entrepreneurial Support Systems) is also an important basis. This theory emphasizes that startup growth is greatly influenced by structured support, such as training, mentoring, access to markets, and technological infrastructure. Thus, incubation programs that are systematically designed and tailored to needs will be more effective in helping startups reach a stable growth stage.

Several previous studies have also strengthened the importance of the role of incubation programs in driving startup success. Hausberg and Korreck's (2021) research shows that technology-based business incubators contribute significantly to facilitating the process of developing ideas into sustainable businesses through the provision of physical and non-physical services. On the other hand , Gonzalez-Uribe and Leatherbee (2022) emphasize the importance of an ecosystem-based approach in incubation programs, which includes intensive mentoring, technology access, and strong industry connections.

Findings from previous research also revealed various obstacles in implementing incubation programs, such as lack of quality mentorship, limited access to funding, and program design that does not match the specific needs of startups. This problem shows the importance of adjusting the incubation program to the development stage and business sector of each startup so that the results achieved are more optimal.

RESEARCH METHODS

This study uses a quantitative approach with descriptive and explanatory designs to analyze the effectiveness of technology-based business incubation programs in supporting startup growth. The main focus of the study is to identify the influence of key elements in incubation programs such as access to funding, quality of mentoring, technical support, and market access on the sustainability and development of technology startups.

The population in this study consists of technology startup actors who have participated in incubation programs in various countries. The research sample was taken purposively from 150 respondents, consisting of startup founders, incubator managers, and mentors, according to the context analyzed in previous findings using NVivo software.

Data collection was conducted through in-depth interviews that were coded and analyzed using text mining and qualitative coding techniques. In addition, word frequency analysis, node hierarchy analysis, matrix coding, sentiment analysis, and thematic analysis were conducted to identify thematic patterns and relationships between variables. An analysis model was developed to understand the relationship between key variables in the incubation program and the level of startup success.

The collected data was analyzed using inferential statistical methods such as Pearson correlation analysis and crosstab analysis to test the strength of the relationship between variables. Testing the validity and reliability of the instrument showed adequate results, with the Kappa coefficient in several fundamental categories reaching >0.75, which indicates a high level of agreement between codes. Interpretation of results refers to general standards of interpretation of social statistics.

The research model in this study places the effectiveness of the incubation program as the dependent variable, while access to funding, mentorship quality, technical support, and market validation as independent variables. In this model, the relationship between variables is explained through the results of correlation analysis and code density that indicate dominant problem areas. For example, the results of matrix coding show that low mentoring quality is strongly correlated ($r = 0.78$) with low startup survival rates.

RESULTS AND DISCUSSION

This study analyzes the effectiveness of technology-based business incubation programs in supporting startup growth through qualitative analysis using NVivo software on 150 in-depth interviews with startup founders, incubator managers, and mentors from 25 countries. The results of the study are presented through various complementary analysis techniques to provide a comprehensive understanding of the problems and effectiveness of incubation programs.

4.1.1 Effectiveness of Technology-Based Business Incubation Programs in Supporting Startup Growth and Sustainability at Various Stages of Development.

Word frequency analysis identified five main problem categories that were most frequently mentioned in interviews with respondents. The findings showed that funding access was the most dominant problem with a coverage rate of 23.4% and a frequency of occurrence of 1,247 times in the entire data corpus. The second position was taken by the quality of mentorship (21.8% coverage, 1,156 frequencies), followed by market validation (18.5% coverage, 982 frequencies).

The distribution of problems shows a high concentration in the top three categories, which cumulatively account for 63.7% of all identified problems. These findings indicate that

most incubation programs fail to provide effective solutions to fundamental areas in technology startup development.

The figure above presents a bar chart showing the coverage percentage of each problem category identified in the research process of technology startup incubation programs. Based on this visualization, the Funding Access category occupies the highest position with a coverage percentage of almost 24%. This shows that obstacles in obtaining funding are the most dominant issue faced by startup actors. Following in second place is Mentorship Quality with a coverage of nearly 22%, which reflects the importance of the role of mentors in helping develop startup strategy and managerial capacity.

The Market Validation category is in third place with a coverage of around 18%, indicating that many startups have difficulty in ensuring that their products or services truly match market needs. Furthermore, Technical Support and Network Building each have a coverage of around 16% and 14%, indicating that even though they are at the bottom of this graph, both still have an important role in supporting the continuity and growth of startup businesses. Overall, this graph confirms that these five main categories are the main focus that needs to be considered in designing a more effective and responsive incubation strategy to startup needs.

The pie chart in the image above illustrates the proportional distribution of coverage of the five main categories of problems faced by startups in the incubation program. Based on the visualization, it can be seen that access to funding (Funding Access) is the most dominant problem with a percentage of 23.4 % . This shows that obstacles in obtaining funding sources are still a major challenge for most startups.

The next category is the quality of mentorship (Mentorship Quality) which has a coverage of 21.8 % , indicating that many startup players feel that the guidance they receive is still not optimal to support business growth. Market Validation is in third place with 18.5 % , indicating the difficulty of startups in adjusting products to actual market needs.

Technical Support and Network Building each have a proportion of 16.3% and are smaller than 16%, indicating that although they are in a lower proportion than the previous three categories, both remain an integral part of the incubation process because they are directly related to product capabilities and business connectivity. Overall, this diagram shows that the most frequently occurring problems in incubation programs are fundamental and require special attention in the preparation of startup assistance policies and strategies.

Table 8. Word Frequency Analysis - Main Problems of Incubation Program

Category Issue	FrequencyCoverage (%)
Funding Access	1.24723.4
Mentorship Quality	1.15621.8
Market Validation	98218.5
Technical Support	86716.3
Network Building	74314

The results of the study show that funding issues are the most dominant problem faced by startups in technology-based incubation programs. Based on word frequency analysis of the entire interview data corpus, it was found that access to funding occupies the highest position with a coverage level of 23.4 % and a frequency of mention of 1,247 times. This confirms that limited funding is a major obstacle to startup growth, both in the early stages and when expanding . Furthermore, the problem of mentorship quality emerged as the second most frequently mentioned issue with a coverage of 21.8 % and a frequency of 1,156 times. Market validation is also a significant concern with a coverage of 18.5 % and a frequency of mention of 982 times. The three categories, cumulatively covering 63.7 % of all identified problems, indicate a fairly high concentration of problems in the fundamental aspects of startup business development. In fourth and fifth positions respectively are technical support (16.3 % coverage, 867 frequencies) and network development (14.0% coverage, 743 frequencies). Although both have a lower proportion than the three main problems, both still have high operational significance. Technical support plays an important role in the product development process and solving technological problems, while network building is key in opening market access and strategic collaboration opportunities. Overall, these findings indicate that many incubation programs are not yet fully effective in addressing the basic needs of startups, especially in terms of funding, mentoring, and market validation.

Technical support is in fourth place (16.3% coverage, 867 frequencies), while network development is in fifth place (14.0% coverage, 743 frequencies). Despite having a lower percentage, these two categories remain significant because they are directly related to a startup's ability to develop products and access markets.

4.1.2 Key Factors Influencing the Success and Failure of Technology Incubation Programs in the Startup Ecosystem.

Based on the research results obtained from the analysis of word frequency and distribution of interview data coverage of startup actors in the technology incubation ecosystem, five main factors were found that most influenced the success and failure of the incubation program. The first and most dominant factor is funding access, with a coverage rate of 23.4% and a frequency of occurrence of 1,247 times in the entire data corpus. This finding shows that most startups consider funding constraints as the main obstacle in the incubation process, especially in the early development and market expansion stages.

Table 1. Key Factors of Technology Incubation Programs Based on Frequency and Coverage

No	Category ProblemFrequency of OccurrenceCoverage (%)
1	Funding Access1.24723 ,4 %
2	Mentorship Quality1.15621 .8 %
3	Market Validation98218 ,5 %
4	Technical Support86716 ,3 %
5	Network Building74314 ,0 %
	Total4.995100%

The second factor is the quality of mentorship, which has a coverage of 21.8 % with 1,156 occurrences. Respondents complained that incubation programs often provide mentoring that does not match the specific needs of startups, both in terms of technology, marketing, and business strategy. This has an impact on the lack of improvement in the startup's internal capabilities during the incubation program.

The third factor is market validation which is recorded with a coverage of 18.5 % and a frequency of 982 times. Many startups have difficulty in understanding whether the products or services they develop are really needed by the market. The lack of support in conducting market testing and feasibility studies is a significant obstacle that contributes to startup failure after the incubation program ends.

The fourth factor is technical support which covers 16.3 % with 867 times mentioned by respondents. The technical support in question includes access to technology facilities, professional technical assistance, and provision of product development resources. Many incubation programs do not have an adequate technology ecosystem to support the specific needs of digital, AI, or IoT-based startups.

The last factor is network building which received 14.0% coverage and was mentioned 743 times. Limited access to strategic networks such as investors, industry partners, regulators, and user communities makes it difficult for startups to develop optimally. Incubators that do not provide business meeting forums or partnership connections are considered less effective in supporting startup expansion.

Cumulatively, the top three factors (access to funding, mentorship quality, and market validation) account for 63.7 % of all identified issues. This suggests that incubation programs tend to be suboptimal in addressing the fundamental needs of startups. While the other two factors, although smaller in percentage, still have an important role in shaping the success of the incubation ecosystem as a whole. Therefore, structural improvements are needed in the design of incubation programs, starting from strengthening capital access, increasing mentor capacity, providing a systematic market validation mechanism, to building a wider and more inclusive network.

CONCLUSION AND SUGGESTIONS

Based on the results of qualitative data analysis conducted on 150 in-depth interviews from global startup ecosystem players, it can be concluded that technology-based business incubation programs do play an important role in supporting the growth and sustainability of startups, especially in the early stages that are prone to failure. However, the effectiveness of these programs still faces serious challenges in their implementation.

First, word frequency analysis shows that access to funding is the most dominant problem faced by incubator participants, with a high frequency of 1,247 and coverage of 23.4%. This problem is followed by the quality of mentorship and the market validation process. This shows that although incubation aims to overcome the main obstacles in startup development, in reality, vital areas such as funding, mentorship, and validation are still not optimally addressed.

Second, through node hierarchy analysis, it was identified that problems in incubation have a layered structure, starting from fundamental issues such as strategic direction (78%), resource allocation (72%), and program structure (69%), which then have an impact on operational issues such as mentor-mentee mismatch (65%) and limited industry connections (58%). These problems ultimately result in specific issues such as lack of specialist knowledge and work culture barriers.

Third, correlation analysis between variables (matrix coding analysis) reveals a systemic relationship between problems, such as a strong correlation between low mentorship quality and low startup survival rates (Pearson $r = 0.78$) . This strengthens the argument that incubation success cannot depend on one aspect alone, but requires a holistic approach that integrates various elements.

Fourth, sentiment analysis shows that the majority of respondents (67.3%) have negative sentiments towards their experience in the incubation program, with words such as "frustrated", "disappointed", and "inadequate" appearing most frequently. This is a strong indication that there is a large gap between participants' expectations of the incubation program and the reality they face in the field.

Fifth, from the thematic analysis, seven main themes of the problem were identified, with the "one-size-fits-all approach" being the most prominent (34.2 %). This indicates that many incubation programs are inflexible and poorly tailored to the specific needs of each startup, both in terms of growth stage, industry sector, and geographic location.

Sixth, the results of the crosstab analysis show that the problems faced by startups differ depending on their stage of development. For example, early-stage startups face the most challenges with market validation (78%), while in the growth and maturity stages, the issues that arise relate to scaling and global expansion. This reinforces the need for differentiation of incubation programs based on startup phase.

Seventh, coding density analysis provides a priority map of areas that need to be fixed, with access to funding and investment at the top (density score 15.7) , followed by mentorship (14.2) and product technical development (12.9). This provides a clear direction for redesigning incubation programs so that they can be more targeted in answering the real needs of startups.

Overall, technology-based business incubation programs need to be reformulated with a more personalized, structured, and data-driven approach. Tailoring the program to the specific needs of each startup, improving the quality of mentors, strengthening industry connections, post-incubation support, and increasing collaboration with investors and other external parties are crucial steps to increase the success and sustainability of startups. Regular evaluation of the effectiveness of the program is also a must to maintain its relevance and driving force in the dynamic entrepreneurial ecosystem.

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