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Building Human Capital in the Sukoharjo Violin Industry: A Harmony Between Profit and Acoustics

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Abstract

Acoustic music instruments, particularly violins, have high market value and export potential; however, the violin industry in Mancasan Village, Sukoharjo, faces sustainability challenges due to limited access to modern production technology, weak business management skills, and low innovation capacity, while craftsmen must balance commercial demands with artistic quality. Despite these constraints, limited research has examined human capital as a strategic intangible asset in strengthening innovation within traditional industries. This study aims to analyze the application of human-capital-based innovation to enhance the competitiveness of the local acoustic violin industry. The research employed a modified Research and Development approach based on the seven steps of the Borg and Gall model, with data analyzed using the Three Box Method to measure changes in knowledge, skills, and entrepreneurial intention following training and mentoring interventions. The results indicate significant improvements in all three aspects, with knowledge increasing by 84.61 percent, skills by 81.37 percent, and entrepreneurial intention by 85.59 percent, all categorized as high. The integrated innovation model combined intellectual capacity development with entrepreneurship training, Android-based financial systems, web commerce, and gallery management, resulting in improved technical competence, structured financial management, digital marketing adoption, and enhanced product competitiveness. In conclusion, human-capital-based incremental innovation effectively strengthens industrial capacity and business sustainability in traditional SMEs, supporting SDG 9 through innovation-driven industrial upgrading and SDG 8 by enhancing productivity and sustainable economic growth within local Small and Medium-sized Enterprises (SMEs).

Keywords: Human Capital; Knowledge Management; Small and Medium-sized Enterprises; Violin

SDGs: Goal 9 (Industry, Innovation and Infrastructure), Goal 8 (Decent Work and Economic Growth)

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INTRODUCTION

Human resources are the intellectual actors behind the scenes who determine the success of an industry, especially in the creative industry where technology is a tool that can be easily copied and pasted, so it is the role of humans that dominates in sparking creativity and facilitating innovation (Redín *et al.*, 2023). One of the growing subsectors of the creative industry is the music arts subsector, which grew by 3.94% in 2021, with

a value of US\$440 million and employing 70,755 workers (Antunès, 2023). This sub-sector covers various including music production, distribution, and musical instrument craftsmanship (Pizzolitto, 2024). Acoustic musical instruments include acoustic guitars, flutes, and pianos, as well as violins. The acoustic musical instrument industry, including violins, has developed in several regions of Indonesia, with one of its prominent centers located in Mancasan Village, Sukoharjo Regency. Mancasan Village has long been known as a producer of ukuleles, guitars, and violins. This village has long been recognized as a hub for stringed instrument craftsmanship, producing guitars, ukuleles, and violins through the expertise of local luthiers.

The violin industry faces challenges related to tone quality because the best wood, maple, does not grow in tropical climates, so craftsmen seek wood substitutes that approximate the quality of maple, such as mahogany (Kusumaningtyas & Subagio, 2012). Craftsmen must also be able to explore the thickness and thinness of the wood, the curves, and the string holders to ensure that the sound can create a symphony (Fritz *et al.*, 2025). On the other hand, the ornaments attached to the violin body are affiliated with classical values that tend to be European in style, where the finishing techniques are not found in explicit knowledge on the internet or other references. At that point, craftsmen had to think about making modifications and developing their own methods to create European-style violin finishes. In this context, what distinguished craftsmen from one another was how they elaborated on the explicit and tacit knowledge inherent in their capacity as human capital, which triggered innovation in violin products (Latilla *et al.*, 2019). Therefore, the key to success lies in human resources as the factor that arranges the elements attached to the violin as an economic and artistic product.

At the same time, increasing demand for violins from educational institutions, cultural organizations, and music communities presents new market opportunities for local craftsmen. However, the limited number of violin makers, combined with restricted access to modern production technology, creates a gap between market potential and actual industry performance. Although specific data on the demand for violins in Indonesia is not publicly available, this instrument remains one of the most popular and sought-after musical instruments, especially among students and lovers of classical music and orchestras. On the other hand, the number of violin craftsmen in Sukoharjo is relatively limited. Although the violin industry in this region is competitive and unique, there is still a significant gap between the potential and the reality faced by industry players. This is because for most craftsmen in Sukoharjo, violins are not just economic products, but also a form of artistic expression with high value. The artistic and economic value of the violin creates a dilemma between producing violins for profit and maintaining the artistic quality that is the soul of the instrument (Glazer, 2025). This dilemma is exacerbated by limited access to modern production technology, minimal business management training, and a lack of innovation that can increase productivity without sacrificing artistic value (Guo & Ahn, 2023). These obstacles have the potential to widen the gap between the capabilities of local craftsmen and the demands of an increasingly competitive market, thereby threatening the future sustainability of the violin industry (Partarakis *et al.*, 2025).

Based on these conditions, this study aims to examine the role of incremental innovation in strengthening human capital within the Sukoharjo violin industry. The main research question guiding this study is: How can incremental innovation rooted in intellectual capital enhance human capital in the Sukoharjo violin industry? This question highlights the crucial relationship between innovation, local knowledge, and human resource competencies, which, if managed properly, can ensure the sustainability of the violin industry without compromising the acoustic value and cultural identity that form its foundation. A deeper understanding of this relationship will not only provide clear direction for the development of the Sukoharjo violin industry, but can also serve as a model for the development of creative industries based on local wisdom in Indonesia.

METHOD

This study uses a modified Research and Development (R&D) approach with reference to Borg and Gall (Junariyah *et al.*, 2023) through seven steps, which emphasize the process of product development and validation through a series of systematic stages. R&D was chosen because it is capable of responding to dynamic and complex challenges in the context of empowering Violin SME at the Mancasan center in Sukoharjo, which covers technical, managerial, and marketing aspects in an integrated manner (Situmorang & Kustandi, 2024). The participants in this study consisted of 17 violin entrepreneurs operating in the Mancasan Village, Sukoharjo. Participants were selected using a purposive sampling technique, with inclusion criteria including active involvement in violin production and willingness to participate in training and evaluation activities. The selected respondents represent small-scale violin craftsmen with varying levels of production experience, providing a relevant context for evaluating human-capital-based innovation.



Figure 1. Modified Borg and Gall RnD (Junariyah *et al*, 2023)

According to the Figure 1, the first step is to identified potential problems in the form of user requirements in the application of appropriate technology to partner Small and Medium-sized Enterprises (SMEs). The second stage was observation related to issues and projections for the medium-term development plan for Violin SME partner, conducted through interviews with Violin SME partner in Mancasan, namely Mr. Andri and Mr. Agus, followed by direct observation to obtain a picture of the real conditions in the field in terms of production, management, and marketing. The third stage is product design, which involves designing incremental innovation solutions by finding the best finishing methods and alternative materials to replace maple wood at a lower price without compromising the quality of the violin design, as well as marketing support through the website. The fourth stage involves design validation with instrument setup, tone alignment using stem techniques, and understanding repairs with violin repairs and maintenance processes. The fifth stage involves design revision, violin shape adjustment, implementation of selected wood with maintained quality, and refinement of promotional strategies. The sixth stage is product testing, which is the implementation of Total Quality Management to ensure that the frame and body of the violin are securely attached. The violin body has vibration and resonance points that meet standards, and the finishing is done as requested without leaving any defects in the painting process. The seventh stage is product revision, which includes technical improvements and marketing strategies before the product is ready for widespread marketing. Through this R&D stage, it is hoped that the resulting violin products will not only meet quality standards, but also be relevant to market needs and able to increase Violin's competitiveness in the Mancasan Sukoharjo center.

Training evaluation was conducted using the Three Box Method, selected because it enables systematic assessment of changes in skills, knowledge, and marketing understanding. The Three Box Method is applied in training evaluation, covering the measurement of changes in skills, knowledge, and understanding of marketing concepts before and after training. Data analysis is conducted qualitatively and quantitatively through data triangulation and descriptive statistics. The questionnaire data were collected and analyzed descriptively by calculating index values. This analysis used the index method to describe respondents' perceptions of the questions asked. The rating scale used in this study ranged from 1 as the lowest value to 10 as the highest value, so the calculation of the respondents' answer index was carried out using the following formula (Ferdinand, 2014). Qualitative data triangulation was carried out by comparing questionnaire results and field observations to ensure data validity and consistency. Ethical considerations were observed throughout the research process, including informed consent from participants and the use of data solely for research purposes.

$$\text{Index Value} = ((\%F1 \times 1) + (\%F2 \times 2) + (\%F3 \times 3) + (\%F4 \times 4) + (\%F5 \times 5) + (\%F6 \times 6) + (\%F7 \times 7) + (\%F8 \times 8) + (\%F9 \times 9) + (\%F10 \times 10)) \div 10$$

(1)

where:

F1 is the frequency of respondents who answered 1.

F2 is the frequency of respondents who answered 2.

and so on, F10 is for answering 10 from the scores used in the list of questions.

Thus, respondents' answers did not start from 0, but from 1 to 10. This results in an index value ranging from 10 to 100, with a difference of 90 and without involving the number 0. To interpret the index value, the

Three-box Method is used, in which the range of 90 is divided into three parts, each with a value of 30. This division forms the basis for interpretation, namely: 10.00% – 40.00% (low), 40.01% – 71.00% (medium), and 70.01% – 100% (high). Based on these references, the researchers then determined the respondents' perception index for the variables used in this study.

RESULTS AND DISCUSSION

Challenges and Opportunities for Violin Makers



Figure 2. The Process of Making a Violin

After the COVID-19 pandemic, violin businesses in Sukoharjo faced a considerable challenge, namely a decline in business turnover. Due to declining demand from key market segments. Changes in consumer behavior, with consumers becoming more selective in their spending, and increased price competition are factors affecting sales (Cavallo & Kryvtsov, 2024). To overcome these problems, violin craftsmen in Muncasan Village, Sukoharjo, such as Mr. Andri, received support in the form of training through strengthening in three main aspects. In line with Figure 2, knowledge induction in the field of production is built through several techniques that ensure the body of the violin is sturdy, the curves on the ornaments are made with precision, and the sanding process ensures that the smoothness meets quality standards. This process emphasizes the capability of human resources to develop methods that facilitate a concise and efficient production process, such as combining similar patterns. Production timeliness is important because almost all violin-making processes are done manually and rely on the craftsman's skills.

A conducive working environment, such as proper lighting, is needed to ensure that craftsmen can work neatly and with attention to detail (Garg *et al.*, 2023). In the finishing process, human resources are required to develop painting methods that are affiliated with trends brought by Western countries. The painting process in developed countries uses computerized and robotic finishing techniques for violins, but craftsmen as executors must be able to respond to these trends by implementing painting techniques that rely on individual skills. In this technique, craftsmen need to draw on their explicit and tacit knowledge to be able to compete with violin products from developed countries. Explicit knowledge is knowledge that can be easily documented, communicated, and learned through formal language, numbers, or symbols. Explicit knowledge tends to be systematic, easy to share, and can be learned directly, providing a structured and measurable foundation. At Violin SME partner, explicit knowledge is used to create patterns, sizes, and models of violins. Meanwhile, tacit knowledge is personal knowledge that is difficult to express because it is inherent in individuals in the form of experience, intuition, skills, and insights (Gamble, 2020). Tacit knowledge is contextual, deep, and can only be acquired through real experience or social interaction (Nonaka & Takeuchi, 1998). Thus, bringing uniqueness, creativity, and personal sensitivity that cannot be replaced by machines. At Violin SME partner, tacit knowledge is implemented by partners when determining the thickness of wood, measuring the moisture content of wood, and determining the dryness of wood for violins. In addition, tacit knowledge is also used in adjusting resonance, motifs, and effective working methods in developing European-style violins. This is in line with the Knowledge Based View theory that tacit knowledge is developed as a resource that is capable of building innovation and competitive advantage in the products created. Therefore,

systemic management is needed to create new knowledge through the implementation of knowledge management in the acquisition, sharing, and storage processes.

Then, when working on violin covers, the spray produced by the nozzle has a density that can damage the lungs, disrupt concentration, and interfere with the respiratory tract due to its very strong odor. Given this production problem, it is mandatory for craftsmen to use standard masks that ensure that residual painting pollutants do not interfere with the health of the craftsmen, making masks and PPE strategic tools involved in the production process (Sabir *et al.*, 2024). Consistent monitoring of air quality in the workspace becomes essential to minimize long-term health impacts. Additionally, awareness on safe handling of finishing materials further enhances the craftsmen's ability to maintain both productivity and well-being.

To strengthen this transition process, knowledge induction for the Violin SME partner was carried out through training in business management, stock monitoring, and financial record-keeping using *Buku Warung*. *Buku Warung* was used because it can facilitate all financial preparation matters for Violin SME partner (Ozbayoglu *et al.*, 2020). The use of this technology has had a direct strategic impact on Violin SME partner (Hermawan & Suharnomo, 2020). Violin SME partner is also equipped with an understanding of the importance of strategic planning, market analysis, operational management, and performance evaluation, which aims to shape a data-driven entrepreneurial mindset. Financial training also focuses on separating personal and business finances. This aims to build the managerial capacity of SME players so that they are able to manage their businesses professionally, efficiently, and sustainably, and are ready to grow to a larger scale.

With regard to market development, the initiative was reinforced by the creation of a website and the establishment of a physical gallery to support promotional activities and expand market reach. Web-commerce has been developed to help partners reach a wider market online, make it easier for customers to access product information, and facilitate the ordering process (Wijayanto *et al.*, 2024). The website will help Violin SME partner digitize their marketing and build their branding in the digital age. On the other hand, the physical gallery serves as a showcase to display products directly to local and out-of-town consumers, opening up wider market opportunities (Breugelmans *et al.*, 2023). The implementation of digital solutions such as *Buku Warung* and Web-Commerce faced several challenges. The main obstacle was the artisans' unfamiliarity with digital technology, as financial records had long been managed manually, requiring time for adaptation. Through gradual training and mentoring, they eventually became able to use digital bookkeeping independently.

The Condition and Innovation of the Violin Industry in Sukoharjo

Sukoharjo has long been known as the center of the violin industry in Indonesia, but the number of craftsmen has declined due to a lack of regeneration and increasingly complex market challenges. In these circumstances, the key strategies that can be implemented to maintain the business are creativity and innovation (Fahmi *et al.*, 2023). The innovation carried out by Violin SME partner is incremental innovation, which is a short-term development approach that focuses on small improvements to refine existing knowledge, skills, and competencies to improve product quality (Yusof *et al.*, 2023) so that it can maintain its existing market share (Zhang, 2022). An example of its application at Violin SME partner is finding the best finishing method and alternative materials to replace maple wood, such as mahogany, which is cheaper without compromising the quality of the violin design, as well as following European designs that have unique characteristics in terms of shape and curves. Then, the process of making Violin SME partner begins with selecting high-quality mahogany wood, which is then cut to size and molded into the body of the violin. The body is then carved according to the model, starting with the upper body, which is attached to the mold, followed by carving the lower body. Once dry, the upper body is removed from the mold, a stan block is inserted into it, and then it is joined with the lower body. Next, the front and back are carved to create a neat shape, sanded, and an F-hole is made. In the next stage, the neck and fingerboard are carved to size, sanded, and then attached to the body of the violin. After that, the sound post and upper and lower blocks are installed. The process then continues to the violin painting process, which begins with filling, sanding, masking the pores, then painting the color as ordered, and finishing with a layer of melamine to make it shiny. In addition to violins, cases are also made by measuring cardboard according to the size of the violin, cutting and printing it, adding wood, adjusting the shape, installing the box, and coating it with fur to make it strong and neat.

The violin has several main parts, including the body, neck, fingerboard, bridge, f-holes, tailpiece, chinrest, tuning pegs, and fine tuners. The body of a violin functions as a sound resonator and consists of a top plate, ribs, and a back plate, which are usually made of high-quality Tonewood such as spruce and maple. The neck of the violin supports the fingerboard, which is where the strings are pressed to produce notes, while the

bridge serves to transmit the vibrations of the strings to the body of the violin. The chinrest helps violinists keep the violin in position while playing. All components of the violin are designed with precision to produce optimal sound quality and comfort for musicians. This structural harmony ensures that every part works together to create a balanced tonal character. As a result, even small variations in craftsmanship can significantly influence the instrument’s overall performance.

Improvement in Knowledge, Skills, and Entrepreneurial Intention

The training received positive responses from participants. Based on the results of the questionnaire, which was processed using the three-box method, the overall average score was in the high category, with knowledge at 84.61%, skills at 81.37%, and entrepreneurial intention at 85.59%.

Table 1. Three Box Method Analyze “Knowledge”

KNOWLEDGE													
Item Question	Frequency												
		1	2	3	4	5	6	7	8	9	10	Total	
	1	0	0	0	0	0	0	11.76	35.29	29.41	23.53	100	
	2							17.65	17.65	47.06	17.65	100	
	3							17.65	35.29	29.41	17.65	100	
	4				5.88			11.76	23.53	23.53	35.29	100	
	5				5.88		5.88	11.76	29.41	17.65	29.41	100	
	6				5.88		11.76	5.88	23.53	41.18	11.76	100	
Item Question	Value												Index Value
	1	0	0	0	0	0	0	82.35	282.35	264.71	235.29	864.71	86%
	2	0	0	0	0	0	0	123.53	141.18	423.53	176.47	864.71	86%
	3	0	0	0	0	0	0	123.53	282.35	264.71	176.47	847.06	85%
	4	0	0	0	23.53	0	0	82.35	188.24	211.76	352.94	858.82	86%
	5	0	0	0	23.53	0	35.29	82.35	235.29	158.82	294.12	829.41	83%
	6	0	0	0	23.53	0	70.59	41.18	188.24	370.59	117.65	811.76	81%
	Average												84.61%

Table 1 shows the frequency distribution and values of the six analyzed question items. In the Frequency section, the table presents the percentage of participants’ responses for each category, with most responses concentrated in columns 7 to 10, indicating a relatively high level of understanding. The Value section converts these frequencies into numerical scores, which are then calculated into an Index Value, showing the percentage of mastery for each question.

As shown in Figure 3, the training significantly improved participants’ knowledge, with an 86% gain in new knowledge, with an 81% increase in understanding of cash flow management. Efficient cash flow management makes it easier for producers to maintain business capital stability, thereby avoiding financial difficulties in their businesses (Tandean *et al.*, 2024). An 83% increase in understanding of the basic features of shop books, an 86% increase in understanding of the use of shop books, an 85% increase in knowledge of simple marketing management, and an 86% increase in understanding of the importance of innovation. Innovation in business is important because it will drive business performance and growth (Hassan *et al.*, 2024).

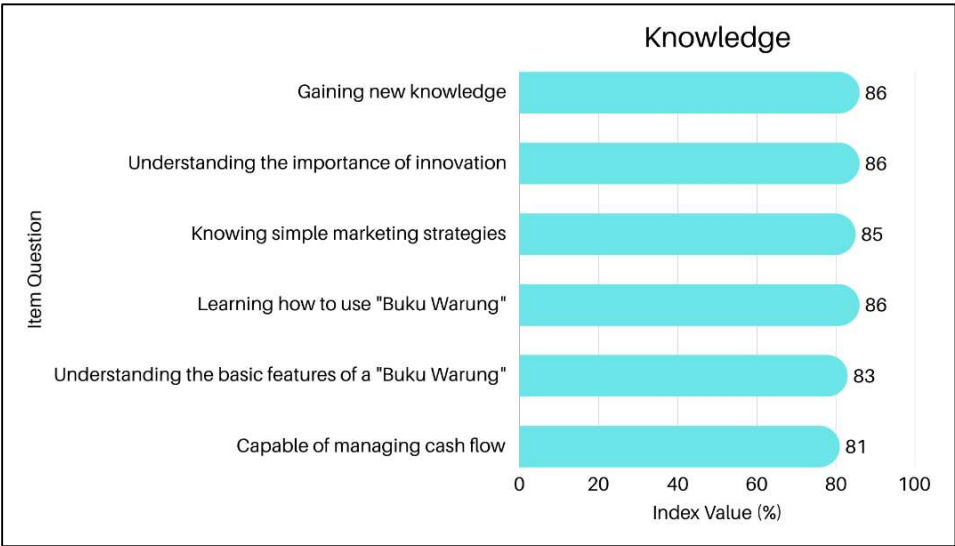


Figure 3. Results of Knowledge Index Data Processing

Table 2. Three Box Method Analyze “Skills”

SKILLS													
Item Question	Frequency												
		1	2	3	4	5	6	7	8	9	10		
	1						5.88	17.65	58.82	11.76	5.88		
	2						5.88	11.76	47.06	17.65	17.65		
	3							11.76	41.18	35.29	11.76		
	4		5.88				5.88	11.76	29.41	29.41	17.65		
	5		5.88					23.53	29.41	23.53	17.65		
	6		5.88				5.88	17.65	29.41	11.76	29.41		
Item Question	Value											Index Value	
	1	0	0	0	0	0	35.29	123.53	470.59	105.88	58.82	794.12	79%
	2	0	0	0	0	0	35.29	82.35	376.47	158.82	176.47	829.41	83%
	3	0	0	0	0	0	0	82.35	329.41	317.65	117.65	847.06	85%
	4	0	11.76	0	0	0	35.29	82.35	235.29	264.71	176.47	805.88	81%
	5	0	11.76	0	0	0	0	164.71	235.29	211.76	176.47	800.00	80%
	6	0	11.76	0	0	0	35.29	123.53	235.29	105.88	294.12	805.88	81%
	Average											81.37%	

Table 2 illustrates the distribution of responses and corresponding values for six assessed skill items. The Frequency section shows the proportion of participants’ answers across categories, with a notable concentration in columns 7 to 10, reflecting generally strong skill levels. Meanwhile, the Value section translates these frequencies into numerical scores, which are then used to calculate an Index Value, representing the mastery percentage for each skill item.

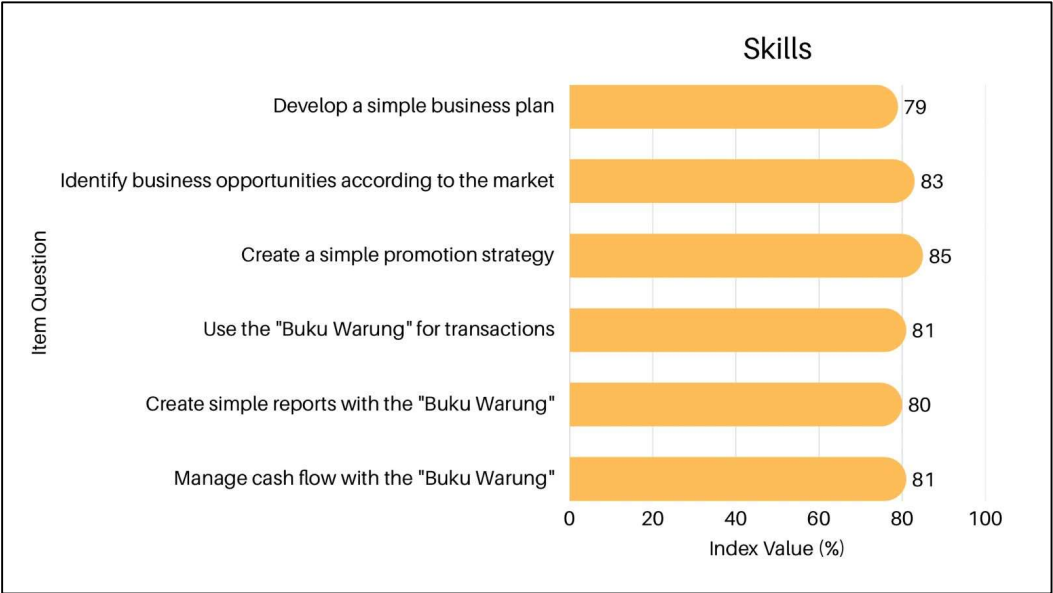


Figure 4. Result of Skill Index Data Processing

As reflected in Figure 4, it shows training participants became more skilled at managing cash flow using *Buku Warung* with a score of 81%, creating simple reports using *Buku Warung* with a score of 80%, using *Buku Warung* for transactions with a score of 81%, creating simple promotional strategies with a score of 85%, and identifying business opportunities in line with the market with a score of 83%. as well as compiling simple business plans with a score of 79%.

Table 3. Three Box Method Analyze “Entrepreneurial Intention”

Entrepreneurial Intention													
Item Question	Frequency												
		1	2	3	4	5	6	7	8	9	10	Total	
	1					5.88	11.76	5.88	23.53	11.76	41.18	100	
	2							17.65	17.65	35.29	29.41	100	
	3							5.88	23.53	41.18	29.41	100	
	4					5.88		23.53	41.18	17.65	11.76	100	
	5						5.88	11.76	41.18	29.41	11.76	100	
	6								41.18	29.41	29.41	100	
Item Question	Value											Index Value	
	1	0	0	0	0	29.41	70.59	41.18	188.24	105.88	411.76	847.06	85%
	2	0	0	0	0	0	0	123.53	141.18	317.65	294.12	876.47	88%
	3	0	0	0	0	0	0	41.18	188.24	370.59	294.12	894.12	89%
	4	0	0	0	0	29.41	0	164.71	329.41	158.82	117.65	800.00	80%
	5	0	0	0	0	0	35.29	82.35	329.41	264.71	117.65	829.41	83%
	6	0	0	0	0	0	0	0	329.41	264.71	294.12	888.24	89%
	Average											85.59%	

Table 3 presents the distribution and values of participants’ responses for six items measuring entrepreneurial intention. In the Frequency section, the table highlights the percentage of responses across categories, with most responses falling between columns 7 and 10, suggesting a relatively strong intention toward entrepreneurship. The Value section converts these frequencies into numerical scores, which are then

aggregated into an Index Value, indicating the level of mastery or strength of entrepreneurial intention for each item.

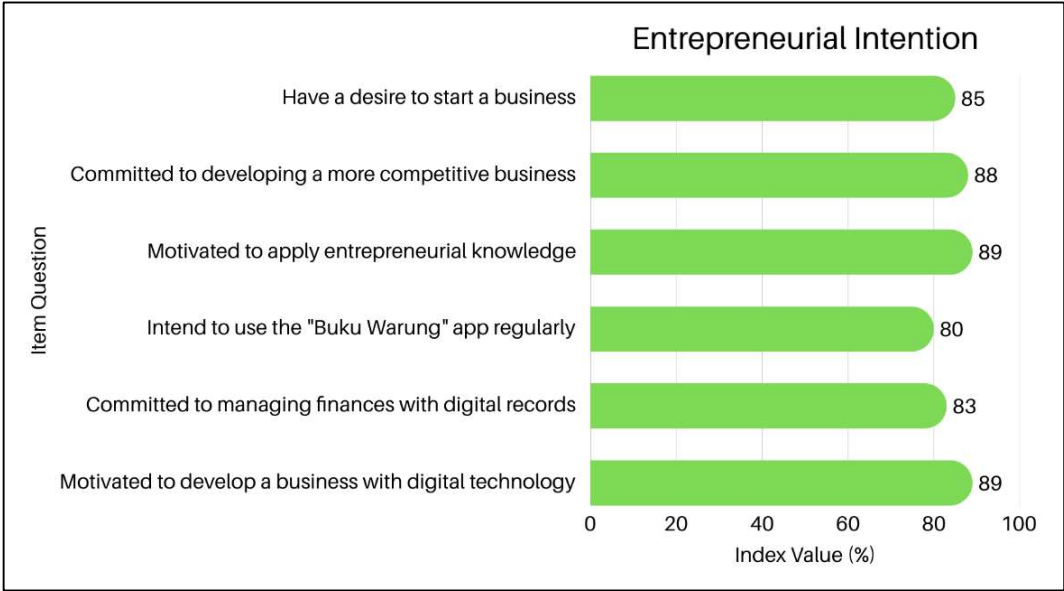


Figure 5. Results of Entrepreneurial Intention Index Data Processing

Based on Figure 5, participants showed motivation to develop businesses using digital technology, with an index value of 89%. SMEs that use digitalization in their businesses will **have a positive impact on performance, productivity,** customer experience, **and** business efficiency (Kádárová *et al.*, 2023). Then committed to managing finances with digital recording with a value index of 83%, intended to regularly use the *Buku Warung* application with a value index of 80%, motivated to apply entrepreneurial knowledge with a value index of 89%, and committed to developing a more competitive business with a score of 88%, as well as having the desire to start a business with a score of 85%.

The questionnaire data analysis shows that the training program has successfully improved participants' knowledge in various managerial aspects, ranging from financial management, digital application utilization, simple marketing strategies, to awareness of the importance of innovation. This improvement reflects the effectiveness of the training activities in strengthening participants' readiness to apply new knowledge in business practices. This improvement not only enhances knowledge but also develops participants' skills in managing businesses in line with current developments in the digital market (Rahmawan & Nurhayati, 2025). Participants are able to apply the material they have learned, from digital financial management in *Buku Warung*, report preparation, to simple business planning, so that their business skills are more focused, measurable, and ready to be applied in their daily entrepreneurial activities.

Following the training, participants also demonstrate stronger entrepreneurial intentions, evident from their high motivation to utilize digital technology, commitment to digital-based financial management, and desire to develop more competitive businesses. This is in line with participants' comments that the activities were “very useful” and “enriched their knowledge,” encouraging them to better understand the importance of financial record-keeping. Participants also hope that the training will be conducted regularly, not too intensively so that the material can be maximized, and supplemented with ongoing assistance both online and offline. Another hope expressed is for ongoing communication and expansion of the program to more SME partners. This shows that with the support of facilities and assistance, this is an effective adaptive strategy for maintaining business sustainability in the violin craft sector and other SMEs.

Overall, the application of innovation and business strengthening support through community service has a positive impact on developing the knowledge capacity of craftsmen in relation to product knowledge, customer knowledge, and managerial knowledge. Product knowledge is knowledge about production methods, assembly, structure, properties, functions, weight, and product prices (Riis *et al.*, 2003). The product knowledge possessed by Violin SME partner includes an understanding of the concepts, how violins work, the violin production process, and the adjustment of violin resonance. Customer knowledge is an understanding of customer needs, preferences, and behavior (Ourzik, 2022). By understanding customer knowledge,

manufacturers will be able to create competitive product value, increase innovation, improve customer loyalty, and make the right business decisions to increase sales. At Violin SME partner, customer knowledge is reflected in the SME partner's knowledge of customer characteristics and understanding of the momentum to attract consumers according to their needs, including when customers usually buy violins. Managerial knowledge is the managerial knowledge and skills possessed by business actors to manage production, marketing, finance, and customer relations activities so that the violin business can run sustainably and competitively. At Violin SME partner, managerial knowledge is injected through community service activities, including entrepreneurship training, financial systems using *Buku Warung*, Web Commerce training, and assistance with the management of physical exhibition galleries.

Although the training program brought significant positive results, the transition process toward digital innovation faced challenges, particularly regarding the adoption of digital technology, as the implementation of digital solutions such as *Buku Warung* and Web-Commerce was not yet familiar to artisans. Artisans usually manage financial records manually, so adopting technology requires an adaptation period with guidance from the community service team. Research is still limited to the scope of studies focusing on the violin industry in Sukoharjo, so the findings cannot be fully generalized to other creative industries with different characteristics. However, this limitation opens up opportunities for further research to expand the scope of the study area, thereby broadening the understanding of human capital strengthening in the creative industry.

In addition, this research has the potential to have a significant impact on the achievement of Sustainable Development Goal (SDG) 9, namely Industry, Innovation, and Infrastructure, which aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Incremental innovation directly supports SDG 9 by improving the capabilities of artisans, improving industrial processes, and encouraging sustainable innovation in small and medium-sized enterprises. By implementing incremental improvements and utilizing intellectual capital, local industries such as the violin industry can increase productivity, competitiveness, and resilience, which is in line with the goal of promoting sustainable industrialization and encouraging innovation. Furthermore, this research has an impact on the achievement of SDG 8 Decent Work and Economic Growth because the productivity generated from innovation encourages the opening of job opportunities with minimal income differences. The community service program provides a platform to open networks with entrepreneurs in the field and outside who can support each other, thereby facilitating access to resources.

The application of incremental innovation supported by intellectual capital management has been proven to strengthen the competence of craftsmen, encourage creativity, and increase the competitiveness of the violin industry in the global market. This contribution not only strengthens business sustainability at the local level but also supports the development of an adaptive and innovative knowledge-based creative industry. Thus, the results of this study can be used as a strategic step in developing a more sustainable and inclusive creative industry that is in line with the global SDGs agenda.

CONCLUSION

The findings of this study confirm that incremental innovation integrated with effective intellectual capital management plays a significant role in strengthening human capital within the Sukoharjo violin industry. Incremental improvements in design adaptation, material selection, and finishing techniques reflect the dynamic interaction between tacit knowledge, such as experiential expertise in wood selection, and explicit knowledge, including standardized patterns and product models. This interaction enhances craftsmen's technical competence, creativity, adaptability to market trends, and entrepreneurial intention, thereby supporting long-term business sustainability. By positioning human capital as a strategic intangible asset, this study extends innovation discourse within traditional craft-based industries that have received limited scholarly attention. From a practical perspective, the results emphasize the importance of systematically managing tacit and explicit knowledge to improve competitiveness in small-scale cultural industries. The findings provide actionable insights for practitioners and policymakers seeking to foster innovation-driven development in traditional industrial contexts. Nevertheless, the study is limited by its focus on a single local industry and the scope of quantitative indicators used to measure human capital and innovation, which may constrain generalizability. Future research should involve broader samples, comparative or longitudinal designs, and alternative innovation models, including digital integration or radical innovation approaches, to further examine how intellectual capital contributes to sustainable competitiveness in traditional acoustic instrument industries.

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AUTHOR CONTRIBUTIONS

Iwan Hermawan: Conceptualization, Project Administration, and Supervision; **Gita Hindrawati:** Formal Analysis, and Writing – Review & Editing; **Sartono:** Resources and Investigation; **Suharmanto:** Methodology and Investigation; and **Lusiana Rahmawati:** Data Curation and Formal Analysis. All authors have read and approved the final version of this manuscript.

DECLARATION OF COMPETING INTEREST

The authors declare no known financial conflicts of interest or personal relationships that could have influenced the work reported in this manuscript.

DECLARATION OF ETHICS

The authors declare that the research and writing of this manuscript adhere to ethical standards of research and publication, in accordance with scientific principles, and are free from plagiarism.

DECLARATION OF ASSISTIVE TECHNOLOGIES IN THE WRITING PROCESS

The authors declare that generative artificial intelligence (Gen AI) and other AI-assisted tools were used prudently, not excessively, during the research and preparation of this manuscript. Specifically, DeepL was used for translate this manuscript. All AI-generated material was reviewed and edited for accuracy, completeness, and compliance with ethical and scholarly standards. The authors accept full responsibility for the final content of the manuscript.

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