

Smart Ruler as an Innovative Medium for Enhancing the Learning Outcomes of TVET Fashion Program Students: Students' and Users' Perceptions of the Smart Ruler as an Innovative Learning Tool

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Abstract—The manual process of clothing pattern drafting presents a major challenge for TVET Fashion Programme students, as conventional methods require excessive time, extreme precision and involve high costs, while carrying a high risk of measurement errors, repetitive and burdensome. Therefore, an innovative tool the Smart Ruler has been developed to overcome these time constraints, reduce operational costs and improve both ergonomics and accuracy in the teaching and learning of clothing pattern drafting. This study was conducted to evaluate the effectiveness of using Smart Ruler in the teaching and learning of clothing pattern drafting among TVET Fashion Programme students. A 4-point Likert scale survey was used to collect data from a total of 20 respondents, comprising lecturers, students, and fashion designers. Descriptive analysis was employed to examine time, cost, physical fatigue, accuracy and work quality. The results indicate that the Smart Ruler saved more than 50% of the time compared to manual practices and reduced costs within a range of RM20 to RM150. The highest mean scores were recorded for explanation of concepts (Mean= 4.0), followed by quality improvement of assignment (Mean = 3.9) and the enhancement of competitiveness within the local fashion industry (Mean = 3.9). Furthermore, physical fatigue levels dropped by 75% compared to manual methods. Ultimately, it can be concluded that the Smart Ruler significantly enhances the effectiveness of teaching and learning for pattern drafting. This innovation not only accelerates the workflow and improves precision but also possesses the potential to be implemented as a standardized teaching aid across the TVET fashion field.

Keywords: Smart Ruler; Fashion; Clothing pattern; TVET; Drafting

1. INTRODUCTION

The fashion and textile field within Technical and Vocational Education and Training (TVET) plays a significant role in the development of the nation's creative industry (Schwab, 2016). However, the garment pattern drafting process still relies heavily on manual methods that require various tools such as measuring tapes and rulers. This approach is time-consuming, demands a high level of skill, and is prone to measurement errors that can affect pattern accuracy and garment quality (Rahman et al., 2021).

Furthermore, manual pattern drafting contributes to material wastage, increased production costs, and physical fatigue among students due to repetitive and prolonged work (Chou et al., 2021). Although modern technologies such as artificial intelligence (AI) and automation systems have been introduced, their adoption in TVET environments remains limited because of their high cost and limited suitability for practical teaching and learning activities (Yusuf & Harun, 2023).

Therefore, the Smart Ruler was developed as a multifunctional innovation that is simpler, faster, and more practical. It is designed to improve measurement accuracy, save time, reduce material wastage, and enhance the teaching and learning process in TVET fashion education (Mohd Zain et al., 2022).

In terms of future improvements, the Smart Ruler could be further enhanced through the integration of digital technologies, such as a mobile application or digital calculation software embedded within the Smart Ruler, enabling users to perform measurement formula calculations more easily, quickly, and efficiently. Additional features, such as automatic measurement and an audio guidance system, could also be developed to improve user-friendliness, particularly for beginner students. Moreover, the development of an industry-oriented version could be considered to meet the needs of large-scale fashion companies (Chou et al., 2021).

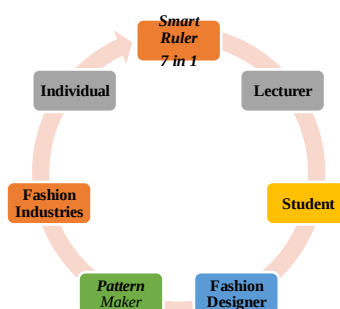


Figure 1. Illustrates the target users of the Smart Ruler innovation.



Overall, the Smart Ruler innovation not only addresses the limitations of conventional garment pattern drafting methods but also demonstrates that creativity and innovation in Technical and Vocational Education and Training (TVET) can produce practical, sustainable, and value-added solutions. The Smart Ruler has the potential to benefit users at various levels, ranging from students to professionals in the fashion industry, while enhancing efficiency and competitiveness.

2. RESEARCH METHODOLOGY

This study employed a quantitative research approach using a questionnaire survey as the primary data collection method. The questionnaire was developed based on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree). A total of 20 respondents, comprising TVET Fashion Programme students and lecturers involved in garment pattern drafting instruction, participated in the study. Purposive sampling was employed to ensure that all respondents were users of the Smart Ruler.

The collected data were analysed using descriptive statistics to determine the mean, percentage, and frequency for each study variable. In evaluating the effectiveness of the Smart Ruler, a quantitative approach was adopted to assess the teaching aid through questionnaire responses and statistical analysis. According to Cohen, Manion, and Morrison (2018), questionnaires are among the most appropriate instruments for collecting extensive quantitative data and enable the analysis of relationships among variables such as time, cost, and measurement accuracy. The research instrument consisted of the following sections:

- Demographic Section – Included respondents' age, occupation, and level of experience.
- Perception Section – Employed a four-point Likert scale (1 = Strongly Disagree, 4 = Strongly Agree) to measure respondents' perceptions of the effectiveness of the Smart Ruler.

Tabel 1. Survey Respondents

No.	Status	Field	Total
1.	Lecturer	Fashion & Apparel	3
2.	TVET Student	Fashion & Apparel	16
3.	Fashion Designer	Fashion & Apparel	1

2.1 Survey Location:

- Politeknik Ibrahim Sultan (PIS)
- Community Colleges offering the Fashion and Apparel Certificate Programme across Malaysia, as well as Fashion Designers in Selangor.

2.2 Respondents' Demographic Profile

- Age: The majority of respondents were between 21–30 years old (students) and 31–40 years old (lecturers/instructors).
- Occupation: The primary respondents were lecturers and students, while a small proportion of respondents were fashion designers.
- Experience: The lecturers had more than six years of experience, whereas the students had one to three years of experience in the fashion field.

3. RESULT AND DISCUSSION

3.1 Research Findings: Perceptions

The application of the Smart Ruler innovation enhances the garment pattern drafting skills of students in the TVET Fashion Programme. A questionnaire employing a four-point Likert scale (1 to 4) was used to collect data on users' perceptions regarding the effectiveness of the Smart Ruler. The data were obtained from 20 respondents to gather feedback on users' perceptions and evaluate the effectiveness of the Smart Ruler innovation in this study.

Table 2. Research Analysis

No.	Item	Score Mean	SD	User Feedback
1	The benefits justify the acquisition cost.	3.7	0.49	Respondents believe that the Smart Ruler offers good value for money.
2	Reduces Physical Fatigue	3.6	0.60	Users feel that it helps reduce physical strain, although the effect is moderate.
3	Helps Lecturers Explain Concepts	4.0	0.22	Lecturers believe that it facilitates teaching and the explanation of technical concepts.
4	Improves the Quality of	3.9	0.37	Students' assignments are neater, faster to complete, and more



No.	Item	Score Mean	SD	User Feedback
	Students' Assignments			accurate.
5	Industry Competitiveness	3.9	0.37	The most significant impact: improving pattern accuracy and accelerating the drafting process.
6	Increases Business Profitability	3.8	0.41	It has the potential to support business performance, although not all respondents perceived its impact to be substantial.

Based on Table 2, the analysis indicates that the use of the Smart Ruler received positive acceptance among the respondents, with average mean scores ranging from 3.6 to 4.0. Overall, the majority of respondents agreed that the Smart Ruler improved the effectiveness of the garment pattern drafting process, particularly in terms of measurement accuracy and time efficiency. These findings demonstrate that the Smart Ruler not only serves as a technical support tool but also provides added value to the teaching and learning process in fashion education.

The most notable aspect was its ability to assist lecturers in explaining concepts, which recorded the highest mean score of 4.0. This finding indicates that the Smart Ruler effectively supports lecturers during instructional sessions by enabling the production of more accurate, neater, and faster garment patterns compared with conventional methods. The Smart Ruler has the potential to become an effective teaching aid because it facilitates clearer and more systematic explanations of measurements, pattern lines, and drafting techniques. In the context of TVET, the use of practical and user-friendly teaching tools can enhance students' understanding and make the learning process more interactive. Measurement accuracy is a critical element in fashion design, as even minor errors can affect the overall quality of a garment. Therefore, these findings suggest that the Smart Ruler improves work efficiency while reducing technical errors during the pattern drafting process.

In addition, respondents expressed positive perceptions of the Smart Ruler's role in improving the quality of students' assignments, with a mean score of 3.9. They believed that assignments produced using the Smart Ruler were neater and better organised, thereby increasing students' confidence in their work. However, the aspects relating to cost-effectiveness and business profitability recorded relatively lower mean scores of 3.7 and 3.8, respectively. This suggests that although respondents acknowledged the Smart Ruler's technical effectiveness, some had yet to perceive its direct economic benefits, particularly regarding business profitability and return on investment.

Overall, this study demonstrates that the Smart Ruler has considerable potential to enhance the quality of teaching, learning, and garment pattern production. Its impact is more evident in technical and pedagogical aspects than in economic outcomes. Therefore, greater emphasis should be placed on promoting its commercial value and long-term effectiveness so that the benefits of the Smart Ruler can be extended beyond educational institutions to the fashion industry and entrepreneurial sectors.

3.1.1 Time Required for Pattern Preparation

- Manual (Conventional) Method: 30 minutes to 2 hours
- Using the Smart Ruler: Less than 15 minutes to 30 minutes

The Smart Ruler reduces pattern preparation time by more than 50% compared with the conventional method.

3.1.2 Cost of Pattern Preparation

- Manual Method: RM50–RM200
- Using the Smart Ruler: RM20–RM50

The significant cost savings make the Smart Ruler a more practical solution for students and small-scale entrepreneurs.

3.1.3 Physical Aspects

- Manual Method: Muscle strain and hand fatigue are commonly experienced.
- Using the Smart Ruler: Fatigue is reduced by 26%–75%, indicating lower physical effort during the pattern drafting process.

3.2 Discussion

The findings support the study by Rahman et al. (2021), which reported that innovative tools in TVET can reduce both the time and cost associated with learning activities. The reduction in physical fatigue is consistent with the principles of ergonomics in technical education proposed by Noraini (2020), which emphasise the importance of user-friendly instructional tools. In terms of measurement accuracy, the present findings are consistent with Lee (2018), who argued that the application of technology in fashion design improves the precision of garment pattern drafting. Furthermore, the findings confirm those of Mohd Zain et al. (2022), who demonstrated that innovative teaching aids support Outcome-Based Education (OBE) by improving the quality of students' work and enhancing lecturers' teaching effectiveness. Overall, this study confirms that the Smart Ruler has a positive impact on students and lecturers in the TVET Fashion Programme. It not only reduces time and costs but also minimises physical fatigue, improves measurement accuracy, enhances the quality of students' assignments, and supports more effective teaching.

3.2.1 Time and Cost Savings

The descriptive analysis revealed that the majority of respondents agreed that the Smart Ruler reduced pattern drafting time by more than 50% compared with the conventional method. This finding is supported by the high mean score for the time-related item (mean = 4.5), indicating a strong level of agreement. In terms of cost, respondents reported savings ranging from RM20 to RM150 per garment pattern project, depending on the project's size and complexity. These savings resulted from reduced use of drafting paper, ink, and additional drafting equipment. The findings are consistent with Gersak (2022), who emphasised that innovation in pattern management can reduce material costs while improving overall efficiency. Figure 2 illustrates the percentage distribution of respondents' reflections regarding time savings and reduced physical fatigue when carrying out the garment pattern drafting process using the Smart Ruler.

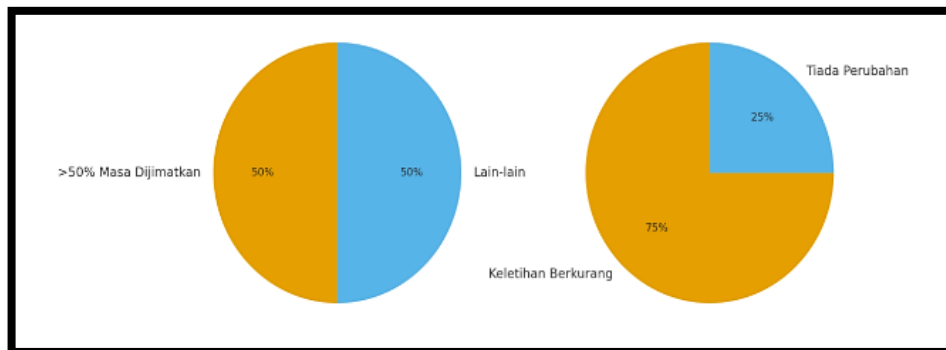


Figure 2. Percentage of Time Savings and Reduced Physical Fatigue During Garment Pattern Drafting

3.2.2 Reduction in Physical Fatigue and Improvement in Task Accuracy

The findings presented in Figure 1 indicate that the use of the Smart Ruler reduced physical fatigue by up to 75% compared with the conventional method. Respondents reported that the garment pattern drafting process became easier, faster, and less physically demanding. These findings are consistent with Shamsuddin et al. (2020), who found that manual pattern drafting often causes hand fatigue, shoulder strain, and back pain among TVET fashion students. In addition, students' task accuracy improved significantly, as evidenced by a mean score of 4.5. This improvement demonstrates that the Smart Ruler minimises the technical errors commonly associated with using multiple conventional rulers. Overall, the findings indicate that the Smart Ruler not only enhances work efficiency but also supports users' ergonomic well-being.

3.2.3 Quality of Student Assignments and Teaching and Learning Effectiveness

The findings also show that the Smart Ruler improved the quality of students' assignments, with a mean score of 3.9, indicating a good level of performance. Students were able to produce garment patterns that were more consistent, accurate, and neatly prepared. From the teaching perspective, lecturers reported improved teaching and learning effectiveness, with a mean score of 4.0, demonstrating that the Smart Ruler also functions as a practical Teaching Aid (TA). Respondents emphasised that this innovation not only simplifies technical tasks but also promotes active and creative learning, allowing students to focus more on understanding design concepts rather than on handling conventional drafting tools. These findings are consistent with Aadenan et al. (2020) and Hanafi et al. (2007), who reported that the use of teaching aids in textile technology significantly enhances students' motivation and understanding.

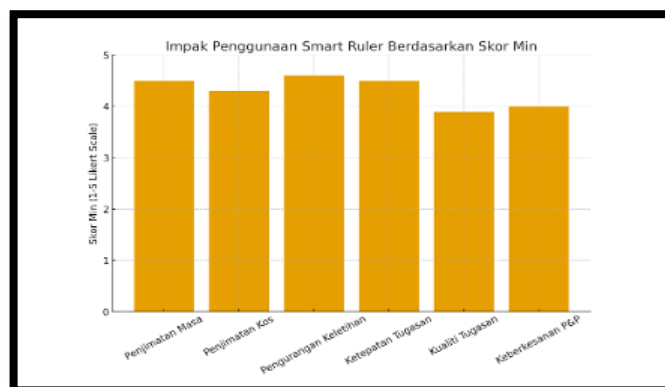


Figure 3. Impact of Smart Ruler Usage Based on Mean Scores for Time, Cost, Physical Fatigue, Accuracy, Assignment Quality, and Teaching and Learning Effectiveness

Figure 3 illustrates the impact of using the Smart Ruler based on the mean scores for time, cost, physical fatigue, accuracy, assignment quality, and teaching and learning effectiveness in practical garment pattern drafting classes. The following excerpts present respondents' feedback on the impact of using the Smart Ruler during practical pattern drafting sessions.

3.2.4 Respondents Feedback

a. Student Respondent

"I find it much easier to draft garment patterns because I no longer need to switch between different types of rulers. My hands also do not get tired as quickly." (Respondent 12, Student)

b. Lecturer Respondent

"The project cost was reduced by almost half because less paper was required." (Respondent 5, Lecturer)

c. Fashion Designer Respondent

"The Smart Ruler has increased my confidence in producing more accurate garment patterns." (Respondent 8, Fashion Designer)

3.3 Commercial Potential and Innovation

The Smart Ruler has strong commercial potential because it addresses market needs in the fashion industry, particularly for students, lecturers, and small and medium-sized fashion designers (SMEs). In terms of financial benefits, the Smart Ruler can reduce pattern drafting costs by RM20 to RM150 per garment pattern project, providing significant added value to users. The Smart Ruler also integrates seven functions into a single ruler, unlike conventional pattern drafting methods that require multiple rulers to produce a garment pattern.

The uniqueness of this innovation lies in its multifunctional design, which combines straight, curved, and right-angle measuring features into one practical tool, making it more competitive than conventional pattern drafting rulers. To protect its intellectual property, the Smart Ruler has been registered with the Intellectual Property Corporation of Malaysia (MyIPO) as an industrial design, packaging design, and Utility Innovation (UI), thereby creating opportunities for large-scale commercialisation (see Figure 4).

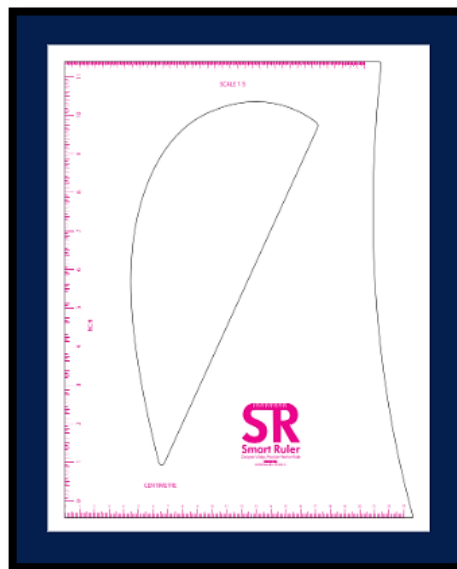


Figure 4. The Smart Ruler Innovation: Seven Functions Integrated into a Single Ruler Design

According to Chou et al. (2021), user-friendly product innovations in technical education have a direct impact on market potential because they meet end-user needs while remaining competitive. Similarly, Lee and Rahman (2022) emphasised that intellectual property protection, such as Utility Innovation (UI) patents, increases the commercialisation potential of innovative products by protecting their unique design value.

3.4 Relevance and Adaptability

The Smart Ruler was designed to meet the needs of various stakeholders, including TVET fashion students, lecturers, individual sewing enthusiasts who make their own garments, fashion designers, pattern cutters, pattern makers, and small-scale entrepreneurs. The tool is easy to use and highly adaptable, as it does not require advanced technical skills or extensive training. Consequently, the Smart Ruler is suitable not only for formal educational institutions but also for community skills training programmes, sewing centres, and small-scale garment manufacturing industries. Khan et al. (2020) found that learning tools that can be easily adopted without requiring extensive technical training have a significant positive impact on the effectiveness of TVET learning. Furthermore, Yusuf and Harun (2023) reported that



user-friendly sewing innovations enhance students' motivation while expanding their application within community-based sewing activities.

3.5 Technology Readiness

A prototype of the Smart Ruler has been successfully developed and evaluated through questionnaire surveys and practical testing involving TVET fashion students and lecturers. The effectiveness evaluation demonstrated a reduction of more than 50% in both time and cost, together with improved pattern drafting accuracy. In terms of resource availability, the Smart Ruler can be manufactured using locally available, low-cost materials, making it suitable for large-scale production. According to Kamaruddin et al. (2022), technology readiness in TVET depends on the effectiveness of prototypes tested with students and lecturers. Their findings indicate that cost-effective innovative tools improve user acceptance while accelerating the teaching and learning process. Likewise, Kim and Lee (2023) highlighted that the availability of local resources plays an important role in strengthening the global competitiveness of educational innovations.

3.6 Technology Transfer Plan and Implementation

The technology transfer strategy for the Smart Ruler will be implemented through the following approaches:

- a. Collaboration with industry and the community, particularly fashion SMEs and vocational training centres.
- b. Development of user documentation and training manuals to facilitate adoption by new users.
- c. Organisation of training programmes and workshops involving TVET students, secondary school teachers (Home Economics subject), and community sewing groups.

Yusuf et al. (2021) found that successful technology transfer in TVET requires close collaboration among educational institutions, industry partners, and local communities. In addition, Ahmad and Rahim (2024) emphasised the importance of training manuals and workshops as effective mechanisms for accelerating users' adaptation to new technologies.

3.7 Project Impact and Effectiveness

From an economic perspective, the Smart Ruler helps reduce operational costs while improving productivity in garment pattern preparation. From social and environmental perspectives, the innovation reduces fabric waste and energy consumption, supporting the principles of sustainability. Stakeholder satisfaction was clearly reflected in the study findings, where the majority of respondents reported improved task performance, reduced physical fatigue, and greater convenience in teaching and learning activities. Lim et al. (2020) demonstrated that innovative equipment in technical education can reduce operational costs by more than 40% while increasing student productivity. Furthermore, Shaari et al. (2024) found that the use of innovative technologies in TVET positively influences user satisfaction, particularly through reduced physical fatigue and improved task effectiveness.

3.8 Sustainability

The Smart Ruler was developed with an emphasis on sustainable technology that is cost-effective, user-friendly, and environmentally friendly. Its long-term application potential is substantial, as it can be used not only in fashion education but also in STEM education, including mathematics, geometry, design, and technology. Future development will focus on incorporating environmentally friendly materials and improving the ergonomic design to ensure that the Smart Ruler remains relevant and sustainable within both educational and fashion industry markets. According to Zhang and Wang (2021), sustainable innovation in technical education should prioritise environmental sustainability, cost-effectiveness, and long-term performance. Similarly, Sulaiman and Othman (2023) reported that the use of eco-friendly materials and ergonomic product designs enhances market acceptance because they align with global sustainability initiatives.

4. CONCLUSION

Overall, this study demonstrates that the Smart Ruler is an effective innovation for addressing several critical challenges in Technical and Vocational Education and Training (TVET), particularly in garment pattern drafting within the fashion discipline. The findings show that the Smart Ruler significantly improves the effectiveness of the teaching and learning process by reducing drafting time, increasing measurement accuracy, and minimising physical fatigue among students. These findings directly address the research problem by demonstrating that conventional manual methods are less efficient due to excessive time consumption, higher costs, and greater susceptibility to measurement errors. The study also found that the Smart Ruler has a positive impact on the quality of students' work. Most respondents expressed a high level of agreement regarding its effectiveness, highlighting significant improvements in pattern accuracy and substantial time savings. These results indicate that the Smart Ruler not only enhances technical performance but also strengthens students' practical competencies in line with current industry requirements. From an educational perspective, the findings support the view that integrating innovative teaching tools into TVET can strengthen learning effectiveness while improving graduates' employability. Therefore, the Smart Ruler can be regarded as a practical and relevant intervention for transforming traditional teaching and learning approaches into more systematic, efficient, and



technology-driven practices. In conclusion, the Smart Ruler has demonstrated considerable potential as an innovative educational tool capable of improving the quality of TVET by enhancing time efficiency, reducing costs, and increasing measurement accuracy. At the same time, it supports the broader goal of transforming skills-based education to meet the demands of 21st-century learning and the future needs of the fashion industry.

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