Intelligent Tutoring System to Establish Hand Knitting Skill in Home Economics Students

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Abstract

This study proposes an Intelligent Tutoring System (ITS) to enhance hand-knitting skills among Home Economics students through AI-driven personalized learning, addressing the limitations of traditional generic methods. The system integrates computer vision, adaptive algorithms, and interactive tutorials to provide real-time feedback and track progress. A study involving 60 students (30 control, 30 experimental) showed the ITS group achieved significantly higher post-test scores, confirming improved proficiency and engagement. Results reveal that the IT IS effectively accelerates skill acquisition and deepens understanding compared to conventional instruction.

Keywords: Intelligent Tutoring System (ITS); Hand Knitting; Home Economics; Adaptive Learning; Computer Vision; AI in Education

1. Introduction

An intelligent tutoring system (ITS) is advanced educational software that integrates artificial intelligence technologies to personalize learning. It adapts to the individual needs, styles, and knowledge levels of each student through integrated models of the domain, student, tutoring, and interface, aiming ultimately to improve educational outcomes with an adaptive and flexible learning experience [1].

Many schools and teachers depend on smart technologies to keep pace with development, particularly in applied fields such as textile education. The application of augmented reality educational media for smart sewing (AR) is relevant for improving student motivation and skill attainment, improving the teaching process for teachers, and teaching sewing topics [2].

Many modern educational systems integrate e-textiles projects into science, technology, engineering, arts, and mathematics (STEAM) programs, as it has a significant effect in linking technical aspects with technology. According to studies in 2024, workshops based on electronic sewing help children to develop computational thinking and recognize electronic circuits, which enhances their ability to link theoretical concepts with practical applications. This confirms the importance of designing an intelligent educational system in the field of textiles that enhances these aspects in an enjoyable and effective educational context [3].

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Intelligent educational systems based on artificial intelligence have been highlighted, especially in micro-applied fields such as the textile industry. Early detection of fabric defects is one of the most prominent challenges facing the industry, which requires training students on artificial intelligence and computer vision tools within interactive educational environments that enhance their practical skills and prepare them for the labor market [4].

With the development of artificial intelligence technologies, it has become necessary to modernize teaching methods applied to skills such as hand knitting. Deep Learning for smart education in computer vision and deep learning is an effective tool for monitoring students' performance and correcting their mistakes, which enhances the quality of practical training to keep pace with labor market requirements [5].

As a result, the knitted fabrics industry has developed in recent years, and has become widely used in many fields, where woven fabrics have become competitive. The art of knitting is one of the oldest arts practiced by humans, which has developed over the ages. Knitting is the second most common method of fabric formation after weaving, and mechanical and manual knitting have expanded in recent years, due to their adaptation to products [6].

The art of hand knitting has a long history, as it was one of the most important means of occupying free time in the past, and today it is in line with the latest fashion lines. Needlework produces different types of clothing and accessories [7].

However, there is a lack of electronic references, educational lessons, or multimedia, and retrieval in the classroom, which has led to a decrease in the skill level of some students in actual practice [8]. Therefore, smart educational systems represent an effective solution for training knitting skills because of the weakness of traditional training. It presents an interactive learning environment that mimics the teacher and helps the student to continuously self-learn with accuracy and confidence [9].

Interactive smart education contributed to shifting students from theoretical understanding to precise practical performance in knitting skills, through systems that evaluate performance systematically and guide learners in real time. Modern models have proven effective in analyzing stitches and converting them into intelligent executive instructions [10].

Research Hypotheses

The main study hypotheses are:

H1: There is a statistically significant difference at the level ($\alpha \leq 0.05$) between the mean scores of the experimental and control group students in the post-test of the cognitive achievement test (as a whole) and at each level of its sub-tests, in favor of the experimental group.

H2: There is a statistically significant difference at the level ($\alpha \leq 0.05$) between the mean scores of the experimental group students in the pre-test and post-test of the cognitive achievement test (overall) and at each level of its subscales, in favor of the post-test."
H3: There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental and control groups in the post-test application of the hand-knitting skills observation checklist (overall) and for each of its individual skills, in favor of the experimental group.

H4: There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental group students in the pre- and post-test of the hand-knitting skills observation checklist (overall) and at each of its skills in favor of the post-test."

Hence, this paper designs an AI-powered intelligent tutoring system to enhance hand-knitting skills for home economics students, presenting real-time stitch analysis and personalized feedback. The system aims to improve learning quality and supply learners with smart tools for efficient skill development. The structure of this paper is organized as follows: Section 2 discusses the related works, Section 3 describes the contributions of the proposed system, and Section 4 presents an implementation for the proposed system, the last section discusses the Experimental results.

2. Related work

Liu, V. S., Latif, E., & Zhai, X. (2025) conducted a comprehensive systematic literature review titled "Advancing Education through Tutoring Systems: A Systematic Literature Review," which analysed 86 empirical studies published between 1972 and 2024. The study divided tutoring systems into three latent classes: computer-based intelligent tutoring systems (ITS), robot-based tutoring systems (RTS), and multimodal hybrid systems. The study recognized notable advancements in personalized learning, emotional engagement, and instructional adaptability using AI-driven techniques such as Bayesian Knowledge Tracing and large language models. Despite the positive effect on student engagement and academic outcomes, the study focused on ongoing challenges related to scalability, ethical concerns (e.g., privacy and algorithmic bias), and the cognitive adaptability of these systems. This study recommends future research to enhance RTS integration, address moral disposition, and ensure similar distribution of such technologies in different educational contexts [11].

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Katarzana Majur Volodarsk (2025) conducted a systematic review, entitled "Artificial Intelligence in the Development of Chinese Crafts," to discover how AI technologies increase traditional Chinese crafts. The study examined indexed literature in Scopus in November 2023 and identified AI-driven pattern generation, smart automation in design, and digital protection of craft techniques as a limited but increasing number of applications. The findings revealed significant research in economic and management aspects of AI integration, in areas such as market expansion, innovation, and durable production. The study assured the importance of interdisciplinary approaches in increasing both technological progress and cultural heritage protection in crafts [12].

Yali Liu and Can Zhu (2025) developed an AI-based education system, called Creative Intelligence Cloud (CIC), that integrates deep learning models (Gans and CNN) into digital art education. The system improved image quality, stability, and user engagement by adapting creative outputs. The study concluded that CIC could change art education by merging technical precision with creative flexibility. Further research is needed to explore its academic applications in real-life settings [13].

Villegas Ch et al. (2025) conducted a study called "Adaptive Intelligent Tutoring Systems for Voice Education: Analysis of the effectiveness of learning effect and learning effect". Research evaluated its effects on learning in voting areas. The individual reaction methods were examined for different student profiles using numbers. The results showed that the adaptive response improved the students' involvement, storage, and performance. The study emphasized the importance of adjusting instruction material based on real-time student data to increase the educational efficiency of the intelligent environment [14].

El Sayegh and Hassaneen (2024) conducted a study entitled "A Study of Generative Artificial Intelligence 'Application and Industrial Design of Robot ...", to find out how generative AI and robotics can install textile design and print. Scientists developed a prototype by combining the AI-gang-raised pattern with robot features such as printing and tool management. The results showed support for better precision, little waste, and sustainable, creative production in textile training and industry [15].

Abdel Haleem, Ibrahim, and Abdel Tawab (2024) conducted a study titled "Utilizing Artificial Intelligence Technical to Develop Some Textile Craft Industries" to investigate how artificial intelligence techniques are used to develop textile artisanship. Moreover, AI technologies are used to increase traditional Egyptian textile crafts. The AD -Integration supports the design processes [16].

Angélique Létourneau et al. (2024) conducted a systematic review on AI-based intelligent Teaching Systems (ITS) in K-12 education. He presented the results of 28 semi-professional studies with 4597 students. The study aims to evaluate the effect of intelligent transport systems based on artificial intelligence on student performance, especially in science, technology, engineering, and mathematics. The results confirmed positive and effective effects on learning compared to traditional teaching methods. According to other interactive or adaptable devices other than AI, the viewing holes were small. Researchers also focused on difficulties in this study design, such as short intervention duration and sample size. He emphasized moral concerns, such as the privacy of student data and algorithm transparency, as problems when using intelligent transport systems in classes. The study demonstrated the ability of AI-controlled intelligent transport systems and emphasized the need for strong, long-term research in different educational environments [17].

Batsaikhan, Z. (Zack) and Correia, A.-P. (2024) presented a study called "Artificial General Intelligence influence on intelligent teaching systems in higher education". The aim is to examine how artificial intelligence and pedigree technologies affected the prosperity and use of intelligent teaching systems in higher education. The study was confirmed by newer advances in devices such as a famine model, multimedia interactions, and a combination of customized teaching systems in information technology. It includes 25 colleagues, reviewed articles published between 2018 and 2023. The results revealed that artificial intelligence improves personal instructions, students' performance, and increases the design. However, the study emphasized moral issues, such as data coverage, algorithm bias, and dependence on AI interaction. Researchers emphasized that although the generic AI teaching system can be converted to more adaptable and responsible platforms, use requires strong moral guidelines and ongoing human inspection [18].

Liu, S., Guo, X., Hu, X., and Zhao, X. (2024) suggested A new generative intelligent teaching system (ITS) architecture based on GPT-4 in their paper "Improving generative intelligent teaching systems using GPT-4: Designing, evaluating and creating a standard framework for future Geth learning platforms". The results showed a significant improvement in grammar, terminology, and sentence structure, in addition to the student's great interest and satisfaction. The system was able to adapt to the reaction and guide students dynamically. This AI-operated interaction is useful for supporting personal learning and improving important thinking [19].

Fernandez Heroro, J., Garcia Holgado, A. and Garcia Benalvo, f.j. (2024) suggested a systematic review, entitled "Emotionally intelligent teaching systems assessing recent development: a scoping review of educational effects and future opportunities". The review examines the integration of emotional sensitivity into intelligent teaching systems (ITS). The study suggests 30 effective intelligent transmission systems that use emotions that detect techniques such as facial expressions, physiological sensors such as electroencephalography, and behavioural tracking. These systems promote teaching methods based on the student's emotional status. He found significant development in student inspiration and engagement, and in some cases, better grades [20].

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Henriikka Vartiainen and Matti Tedre (2023) conducted a qualitative study named "Using Artificial Intelligence in Craft Education: Crafting with Text-to-Image Generative Models" to get to know how to utilize generative AI tools as creative collaborators within craft education. The study involved pre-service and in-service craft teachers participating in a practice workshop where they utilized text-to-image models (such as DALL·E and Midjourney) while constructing designs from written descriptions. The study found that models expanded participants' ideational scope, enabled ideation, and encouraged reflection upon the utilization of AI in creative endeavours. However, participants also expressed concerns about ethical issues, including authorship, copyright, and algorithmic bias. The study concluded that incorporating generative AI in craft education could enhance both innovation and critical digital literacy, if ethical and pedagogical frameworks are clearly established [21].

Konstantina Chrysafadi1, et al. (2023) had proposed a fuzzy-based intelligent tutoring system for computer programming for academic students in Greece and evaluated the user experience, adaptability, and learning outcomes. Results showed that the incorporated fuzzy mechanism to the presented ITS enhances the system with Artificial Intelligence and through this, it increases the learners' satisfaction and new knowledge learning and mastering, improves the recommendation accuracy of the system, the efficacy of interactions, and contributes positively to the learners' engagement in the learning process [22].

Manar Dahbi (2023) had proposed an Intelligent Language Tutoring System in Teaching English Grammar aims to investigate the perceptions of a group of students regarding the effectiveness of this system and its service quality. This investigation is significant since it gives further insights into how Intelligent Language Tutoring Systems can help students learn grammar in a personalized manner based on their levels. The study revealed that classroom teaching could not provide customized instruction and feedback. Therefore, intelligent language tutoring systems can support adaptively to individual learner needs [23].

3. Proposed System

This study aims to develop an AI-driven Intelligent Tutoring System (ITS) for teaching hand knitting skills, based on a previous application in Home Economics education. The system integrates computer vision technologies (ML Kit and Image labeling) to detect practical errors and provide real-time feedback. It also includes student modeling, adaptive lesson sequencing, and personalized instructional content. The study addresses a gap in applying IT IS to craft-based skills and draws on recent research confirming AI's effectiveness in enhancing learning outcomes.

3.1 System Overview

The proposed application aims to benefit from the advantages of modern technology in teaching different disciplines in general and in clothing in particular. The main benefit and contribution of the proposed application is the integration of smartphone applications in learning and training the skill of knitting stitches for home economics students, testing the students in these skills, then evaluating them through the system, and giving the students the final evaluation. Figure1 shows a flow diagram of the proposed system.

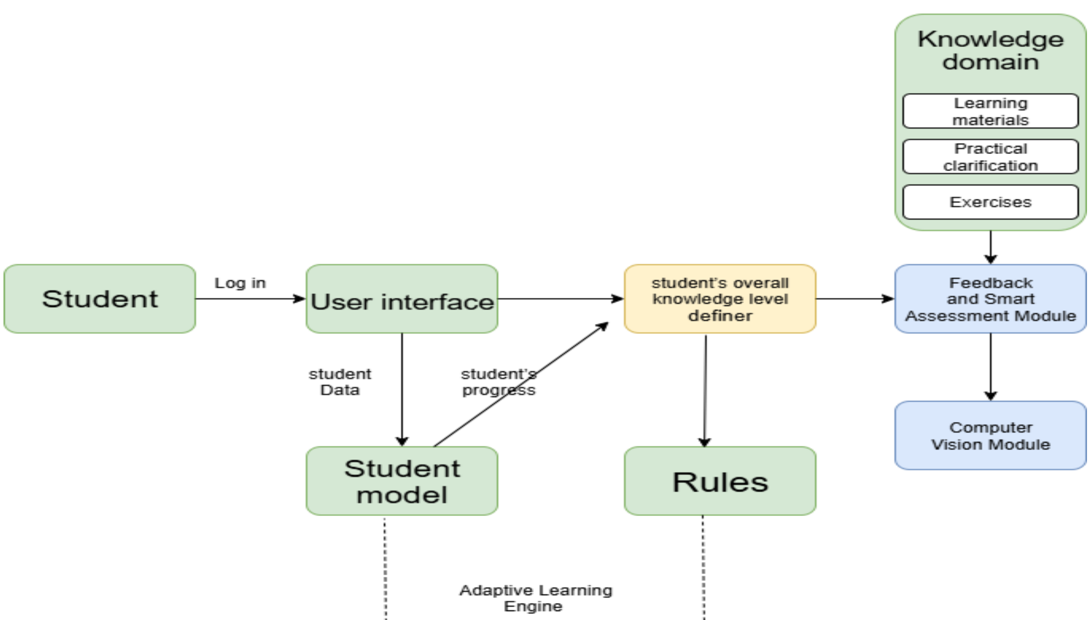

Figure 1. diagram of the proposed system

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From the previous Figure, the components of the proposed system can be summarized as follows:

1. **User Interface**
- Login and Data Entry: The student begins using the system by logging in, entering personal information, and previous experience.
- Content Interaction: Through the interface, the student can access video lessons, short quizzes, and interactive activities.
- Lesson Navigation: The next lesson becomes available only after the student scores at least 75% in the current lesson.

2. **Student Model**
- Store and analyse student data.
- Track the learner's performance development over time.
- Integrate with the Adaptive Learning Engine to personalize content.

3. **Student's Overall Knowledge Level Definer**
- Evaluate the learner's level based on data and progress.
- Send results to the Rules module to determine the next instructional step.
- Determine the most appropriate content or activity through the rules for the learner based on their proficiency.
- Represent the system's decision-making mechanism.

4. **Knowledge Domain**
- Include the educational content:
- Learning materials.
- Practical clarifications.
- Exercises.

5. **Feedback and Smart Assessment Module**
- Receive outputs from the Knowledge Domain.
- Use computer vision to analyse the learner's work.
- Present immediate and accurate feedback.

6. **Computer Vision Module**
- Instant Feedback: Send immediate visual and textual feedback to the assessment module.
- Image Analysis: Analyze images of the student's knitting work using ML Kit and Image labeling technologies. The following pseudocode illustrates the image activity recognition algorithm for knitting-related content.

```
Input: An image 'I' captured or uploaded by the user.
Output: A Boolean flag indicating the presence of knitting-related activity.
Initialize the image labeler with default ML Kit options
Process image 'I' to obtain a list of labels 'L'
Initialize string variable 'Results ← ""'
for each label 'l ∈ L' do
    if Confidence(l) > 0.7 then Append Text (l):: (Confidence(l) * 100) % to Results
end for
Convert 'Results' to lowercase
if 'Results' contains any keyword in {"wool", "knitting", "crochet", "textile"} then
    Display success message: "Knitting or crochet activity detected"
     Proceed with image processing
    Return True
else
    Display alert dialog: "Unable to recognize the image. Please check clarity or relevance"
    Return False
end if
if error occurs during processing, then
    Display error message and log exception
end if
```

- Error Detection: Identifies common mistakes such as missing stitches, pattern mismatches, or size deviations. Figure 2 illustrates the flow chart to detect the error and its types.

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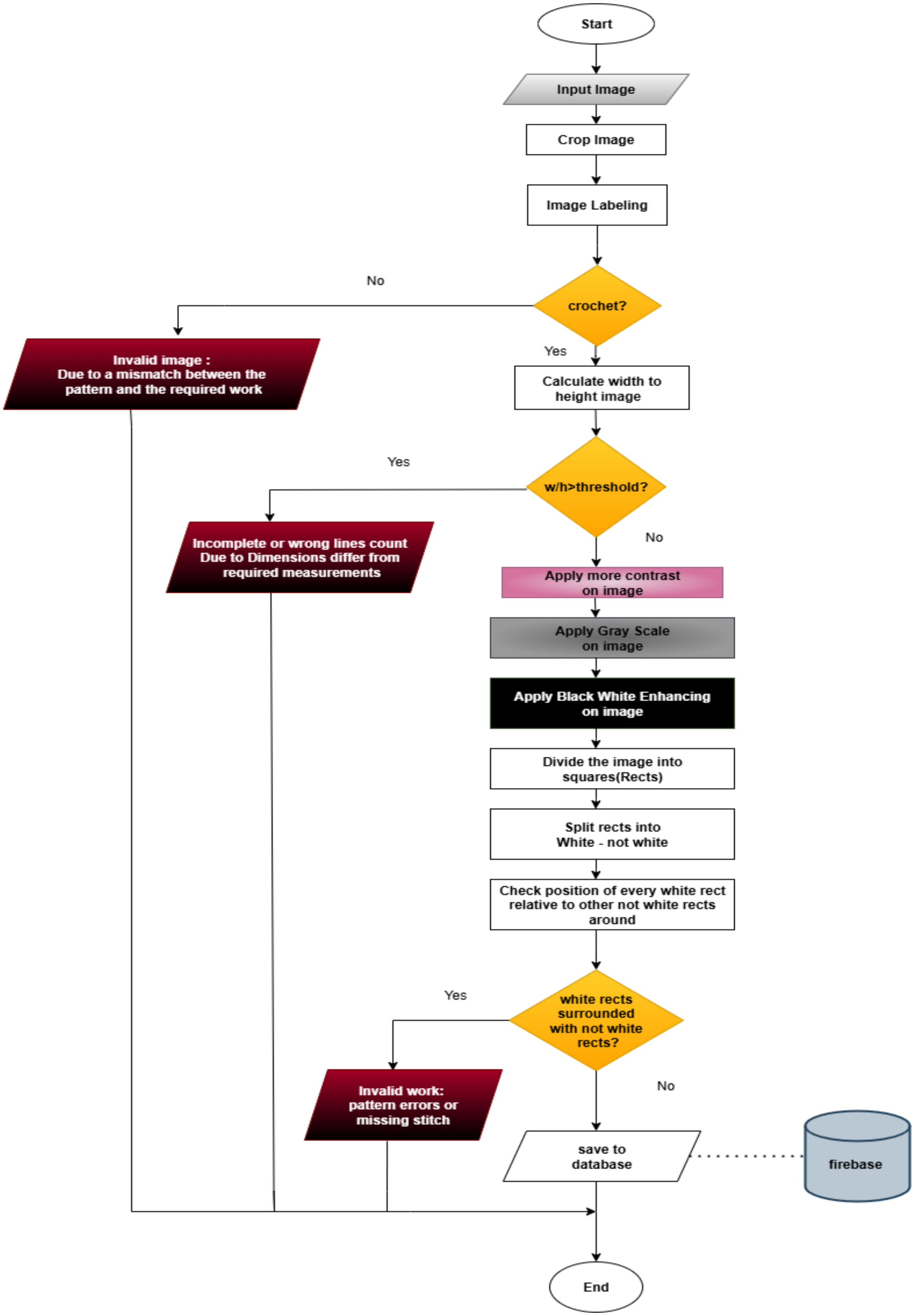

Figure 2. A flow chart illustrating the types of errors identified in the practical activity of knitting stitches.

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3.2 Procedures:

The Intelligent Tutoring System for Hand Knitting Skills follows set of procedures, as follows:

1. Preparatory Stage

- Development of the hand knitting skills list, the intelligent tutoring system standards list, and the instructional content.
- System design and programming using Android Studio, Java, Firebase, and ML Kit.
- Preparation and validation of research instruments (cognitive achievement test and performance observation checklist.

2. Pre-Test Administration

- Administration of the cognitive achievement test and the performance observation checklist to determine each learner's baseline level of theoretical knowledge and practical hand knitting skills.
- Statistical verification of group equivalence before the experimental intervention.

3. System Deployment and Orientation

- Installation and functional verification of the system on students' mobile devices.
- Conducting an orientation session to explain the system's features, navigation methods, and interaction mechanisms.

4. Independent Interaction with the System

- Interacting with the intelligent tutoring system via their mobile device by the learner.
- Presenting adaptive instructional content designed to meet learner responses and performance progression.
- Supporting researcher in case of technical issues or learning difficulties.

5. Formative Monitoring

- Continuous monitoring of learner engagement and system technical performance throughout the training period.
- Real-time feedback generation by the system to address errors and guide skill enhancement.

6. Post-Test Evaluation

- Re-administration of the cognitive achievement test and the performance observation checklist to estimate the effect of system on knowledge acquisition and practical skill mastery.

7. System Evaluation

- Evaluation of the system against educational multimedia standards, including interactivity, content organization, visual clarity, and feedback quality.
- Collection of feedback from learners and subject-matter experts to ensure both pedagogical and technical quality.

8. Data Collection and Statistical Analysis

- Collecting, coding, and analyzing pre- and post-test results using appropriate statistical methods (e.g., t-test, chi-square, and descriptive statistics).
- Explaining findings to assess the system's effectiveness.

9. Maintenance and Future Updates

- Evaluating results, updating or refining the system's content, database, and functionalities.
- Combining additional knitting patterns or other manual skills.

3.3 System Implementation:

The proposed Intelligent Tutoring System was developed using Java 8 in the Android Studio 2022environment, aiming at Android API level 27 (Android 8.1 "Oreo"). It follows to Android SDK development standards and integrates external libraries such as ML Kit (for real-time image analysis), and image processing to enhance visual analysis accuracy.

Minimum Hardware Requirements:

- Processor: Quad-core 1.4 GHz or higher.
- RAM: 2 GB (3 GB recommended for better performance).
- Storage: 16 GB (32 GB preferred).
- Camera5 MP or higher (for knitting pattern analysis).

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- Display: At least 4.7 inches with 720p resolution.
- Connectivity: Wi-Fi or 3G/4G support.

This technical integration has resulted in producing a light, responsive and pedagogically effective mobile learning environment, where the system enables learners to discover errors in knitting patterns and correct them through immediate interactive feedback. The system interface was also designed in a way that focuses on ease of use and achieving educational goals, making it suitable for application in vocational education programs and home economics fields. Figure 3 and Figure 4 show some images from the proposed system.

Figure 3. The main screen of the proposed system

Figure 4. The screen of the Practical activity

4. Experimental Results

After the presentation of the research procedures, the implementation of the main experiment, and the recording of Home Economics students' scores on the research instruments. This section presents the results of the statistical analysis to examine the validity of the research hypotheses and to interpret the findings considering these hypotheses, as follows:

4.1. Hypothesis One :

"There is a statistically significant difference at the level ($\alpha \leq 0.05$) between the mean scores of the experimental and control group students in the post-test of the cognitive achievement test (as a whole) and at each level of its sub-tests, in favor of the experimental group"

The means and standard deviations of the scores of the experimental and control group students in the post-test of the cognitive achievement test (as a whole) and at each level of its sub-tests were calculated. The homogeneity assumption for the two groups was investigated, and an independent samples t-test (t-test for independent means) was applied to compare the mean scores of the two groups. The table summarizes these results.

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Table 1: Shows the t-value and its statistical significance for the difference between the mean scores of the experimental and control group students in the post-test of the cognitive achievement test.

Test	Groups	Mean	Std. Deviation	Independent Samples Test			η2
				t	df	Sig. (2-tailed)	
Knowledge	**Experimental**	18.47	2.64	20.766	58	.000	0.881
	Control	7.97	0.85				
Comprehension	**Experimental**	2.67	0.48	8.255	58	.000	0.540
	Control	1.63	0.49				
Application	**Experimental**	12.30	2.96	11.510	58	.000	0.696
	Control	5.43	1.38				
Academic achievement	**Experimental**	33.43	5.49	17.316	58	.000	0.838
	Control	15.03	1.92				

The results were summarized in the previous table show that the t-value is significant at the (0.01) level, indicating that there is a statistically significant difference between the mean scores of the experimental and control group students in the post-test of the cognitive achievement test (as a whole) and at each level of its sub-tests, favoring the experimental group.

4.2. Hypothesis Two :

There is a statistically significant difference at the level ($\alpha \leq 0.05$) between the mean scores of the experimental group students in the pre-test and post-test of the cognitive achievement test (overall) and at each level of its subscales, in favor of the post-test."

The t-test for related means was used to compare the mean scores of the experimental group students in the pre-test and post-test of the cognitive achievement test (as a whole) and at each level of its sub-tests to test the validity of this hypothesis. The following table summarizes these results.

Table 2: Shows the results of the "t-test" comparing the pre-test and post-test mean scores of the experimental group students in the cognitive achievement test (as a whole) and at each level of its sub-tests.

Test	Application	Mean	Std. Deviation	Paired Samples Test			η2	d
				t	df	Sig. (2-tailed)		
Knowledge	Pre	4.03	0.85	38.022	29	.000	0.980	13.981
	Post	18.47	2.64					
Comprehension	Pre	0.27	0.45	26.382	29	.000	0.960	9.600
	Post	2.67	0.48					
Application	Pre	1.50	1.36	30.263	29	.000	0.969	11.066
	Post	12.30	2.96					
Academic achievement	Pre	5.80	2.06	43.261	29	.000	0.985	15.944
	Post	33.43	5.49					

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The study results revealed a statistically significant difference at the 0.01 level between the mean scores of the experimental group students in the pre-test and post-test of the cognitive achievement test. This difference was in favor of the post-test, both at the overall test level and across its sub-levels. The calculated t-value was (43.261), which is statistically significant at the 0.05 level with 29 degrees of freedom. Accordingly, the second hypothesis of the research, which states: "There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental group students in the pre-test and post-test of the cognitive achievement test in favor of the post-test," was accepted.

Furthermore, the effect size was calculated using the Eta squared (η^2) formula, indicating a value of 0.985. This indicates that 98.5% of the variance in performance can be attributed to the impact of the applied educational system.

It was found that $\eta^2 = 0.985$. When determining the effect size by calculating the effect size, the value obtained from the equation was 15.944. The effect size is categorized as large, medium or small as follows:

$$d = \frac{2\sqrt{\eta 2}}{\sqrt{1-\eta 2}}$$

The reference table 3 to determine the levels of effect size.

Table 3: The levels of effect size

The tool used	Effect size			
	Small	**Medium**	**Large**	**Very large**
D^2	0.2	0.5	0.8	0.9
η2	0.01	0.06	0.14	0.20

This means that the effect size is large, and thus, the first hypothesis is confirmed.

4.3. Hypothesis Three:

“There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental and control groups in the post-test application of the hand-knitting skills observation checklist (overall) and for each of its individual skills, in favor of the experimental group.”

The mean scores and standard deviations for the experimental and control groups' post-test scores on the hand-knitting skills observation checklist (overall) and for each skill were calculated to test the validity of this hypothesis. The assumption of homogeneity of variances between the two groups was verified. Then, a t-test for independent means was applied to compare the mean scores of the two groups.

The table shows the results to indicate whether there is a significant difference between the two groups in the post-test application of the checklist. If the t-value is great significant, it shows that there is a significant difference between the experimental and control groups.

Table 4: Shows t-value and its statistical significance for the difference between the mean scores of the experimental and control groups in the post-test application of the hand-knitting skills observation checklist (overall) and for each skill.

Test	Groups	Mean	Std. Deviation	Independent Samples Test			η2
				t	**df**	**Sig. (2-tailed)**	
Hand knitting	**Experimental**	17.87	0.68	39.411	58	.000	0.964
	Control	7.07	1.34				
Increased knitting stitches	**Experimental**	6.20	0.81	11.687	58	.000	0.702
	Control	3.57	0.94				

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Scaling down knitting stitches	**Experimental**	6.10	0.80	5.558	58	.000	0.348
	Control	4.77	1.04				
Lock knit stitches	**Experimental**	4.53	0.51	2.769	58	.000	0.117
	Control	3.97	1.00				
Hand Knitting Skills	**Experimental**	34.70	1.37	29.117	58	.000	0.936
	Control	19.37	2.54				

The study results indicated a statistically significant difference at the 0.01 level between the mean scores of the experimental and control groups in the post-application of the hand-knitting skills observation checklist—both overall and for each skill—in favor of the experimental group. Accordingly, the thirtieth hypothesis of the study, which states: "There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental and control groups in the post-test application of hand-knitting skills (overall and for each skill) in favor of the experimental group," has been accepted.

Furthermore, the effect size was calculated using the Eta squared statistic, which showed a value of (0.936). This indicates that 94% of the variance in performance can be attributed to the impact of the intelligent educational system in developing hand-knitting skills among home economics students, reflecting a strong and significant effect of the system on students' performance.

4.4. Hypothesis four:

"There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the mean scores of the experimental group students in the pre- and post-test of the hand-knitting skills observation checklist (overall) and at each of its skills in favor of the post-test."

To test the validity of this hypothesis, a paired samples t-test (t-test for correlated means) was used to compare the mean scores of the experimental group students, in the pre- and post-test of the hand-knitting skills observation checklist (overall) and for each skill. The following table summarizes these results.

Table 5: shows results of the "t" test for comparing the pre- and post-test mean scores of the experimental group students on the hand-knitting skills observation checklist (overall) and at each of its skills.

skills	**Application**	**Mean**	**Std. Deviation**	**Paired Samples Test**			**η2**	**d**
				T	**df**	**Sig. (2-tailed)**		
Hand knitting	Pre	4.20	1.10	60.316	29	.000	0.992	22.312
	Post	17.87	0.68					
Increased knitting stitches	Pre	1.63	0.85	24.856	29	.000	0.955	9.022
	Post	6.20	0.81					
Scaling down knitting stitches	Pre	1.83	0.95	20.451	29	.000	0.935	7.345
	Post	6.10	0.80					
Lock knit stitches	Pre	2.10	0.55	17.223	29	.000	0.911	6.105
	Post	4.53	0.51					
Hand Knitting Skills	Pre	9.77	1.81	68.919	29	.000	0.994	25.518
	Post	34.70	1.37					

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The results revealed a statistically significant difference at the 0.01 level between the pre-test and post-test scores of the experimental group on the Hand Knitting Skills Observation Checklist—both overall and across individual skills—in favor of the post-test. The calculated t-value was (68.919), which is statistically significant at the 0.05 level with 29 degrees of freedom. Accordingly, the fourth hypothesis of the study was accepted, stating that: "There is a statistically significant difference at the ($\alpha \leq 0.05$) level between the pre-test and post-test mean scores of the experimental group on the Hand Knitting Skills Observation Checklist, favoring the post-test."

The Eta-squared (η^2) formula was applied, resulting in a value of (0.994) to determine the effect size. This agrees with an effect size value of (25.518), which, according to the reference scale, is classified as a large effect. This confirms the great effect of the intelligent educational system on improving hand-knitting skills, thereby supporting the acceptance of the fourth hypothesis.

5. Conclusion

The proposed Intelligent Tutoring System (ITS) significantly contributes to the advancement of hand knitting education by benefiting from AI-driven image analysis, adaptive learning algorithms, and real-time feedback. Through the integration of computer vision techniques and a structured evaluation pipeline, the system not only detects stitching accuracy but also presents immediate, personalized guidance based on learner performance.

This personalized approach accelerates skill acquisition and supports students in developing precision and consistency in their handwork. Moreover, the modular nature of the system design allows for future scalability and reuse in other educational contexts.

6. Future Work

To enhance the learning experience, the following future directions are proposed:

- Integration of Augmented Reality (AR) and Virtual Reality (VR): To provide immersive, hands-on practice environments for students to simulate and refine handcraft techniques interactively.
- Expansion to additional Home Economics skills: Such as sewing, embroidery, and crochet, using the same AI-based evaluation framework.
- Enhanced analytics dashboard: For instructors to track student progress, common errors, and adapt teaching strategies accordingly.

The continued development of this system aims to modernize practical skill education and bridge the gap between traditional crafts and emerging educational technologies.

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