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The Application of Expert Systems in Manufacturing Sector

Dawit Teklu Weldeslasie, Mehamed Ahmed

Abstract: ***Ethiopia is among the African countries that are following stereotype of Agricultural Development Led Industrialization (ADLI). In fact, textile and garment sector is the second largest manufacturing industry that plays a significant role in the development of Ethiopian economy. However, the textile and garment sector is still in its embryonic stage and the production quality is rather poor, even when compared with other developing countries. In light of this, the researchers argued that the Ethiopian textile and garment sector is not competitive. Behind the low performance of the Ethiopian textile and garment industry, there is also lack of specialized and experienced man power. Therefore, unless a technological improvement of the industry is undertaken, it may not be able to achieve the set objectives The researchers assess the need and application of expert systems in the textile and garment industries. They had also assessed the training programs of both textile and garment industries. As a result, textile and garment industries have not yet applied an expert system, and they have also limited training programs. Therefore, specific training on defect detection is required. In an effort to address such problem, this study recommends to integrate expert system for defect detection of textile faults by designing and developing a prototype. The findings of this research showed 91% (the highest percentage) of the industry workers agreed that a prototype system which considers employee needs shall be constructed. So, the result of this research becomes an input for the prototype system development. Therefore, researches encourage textile and garment industries to implement expert systems.***

Keywords: ADLI, Textile, Garment, Manufacturing, Industry, Expert systems

I. INTRODUCTION

The textile and garment sector is the second largest manufacturing industry that plays a significant role in the development of the Ethiopia's economy. It has vast potential to manufacture goods for export and bring in very much needed foreign exchange. The sector comprises a large number of state owned enterprises and a growing number of private sector participants at all levels *(Negede et al., 2011).*

However, the textile and garment sector is still in its embryonic stage and the production quality is rather poor, even when compared with other developing countries *(Negede et al., 2011).*

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In light of this, *Daniel and Amare (2010)* highlighted that the Ethiopian textile and garment sector is not competitive. Behind the low performance of the Ethiopian textile and garmentindustry, there is also lack of specialized and experienced man power. Therefore, unless a technological improvement of the industry is undertaken, it may not be able to achieve the set objectives *(Negede et al., 2011).*

Each decision in the production lines of textile and garment production depends on the combination of decisions made in the preceding stages *(Ford, 2000).* Similarly, the process of troubleshooting faults is traditionally carried out by human experts and the use of computerized systems exhibiting expert system is not well studied in Ethiopia. The basic idea behind expert system is simply that expertise, which is the vast body of task specific knowledge can be transferred from human to computer. In other words, expert system helps individuals having limited expertise to attain a level of performance closer to that of domain experts; because expert's knowledge is stored inside the computer and users can call upon the computer for specific advice, help, diagnosis and rectification as needed *(Kahraman et al., 2012).*

II. REVIEW OF RELATED WORKS

The main reason behind the low performance of the Ethiopian textile and garment industry is lack of specialized and experienced manpower *(Negede et al., 2011).* There is also a minimum flow of information and cooperation towards achieving a common goal among workers *(Amare, 2006; and Kalayu, 2014).*

In addition, excessive downtime remains a problem for many textile and garment industries, particularly those using complex capital intensive manufacturing processes *(Davies and Greenough, 2006).* High rate of turnover of skilled workers and absence of research and development within these industries for providing immediate solution to the problems are also some of the observed causes of incapability arise internally at textile and garment industries of Ethiopia *(Negede et al., 2011).*

Even though top priority is given to the sector in transferring of technology; *Negede et al. (2011)* indicated a technological gap and cause of incapability of the Ethiopian textile and garment sector in international market through analysis of their production techniques, quality control and assurance policy, maintenance system and level of technology used.

Many international textile and garment manufacturing industries use information technology to support various aspects of their maintenance activities including breakdown diagnosis *(Davies and Richard, 2006).*

One form of information technology for textile and garment industries is the introduction of expert system into their diagnosis and rectification processes. Even though expert system can be among the most useful solutions for the textile and garment industry, many workers are facing challenges in using and adapting technological solutions due to lack of the required knowledge of English language instead of their local language *(Korgaonkar and Khera, 2007).*

Hence, suitable content should be represented in the language of the people, because use of local language is highly essential in digital world *(Dawit, 2003; and Ganesan and Siva, 2007).* This is also supported by *Byamugisha (2013)* where localized technologies were found to be better adopted in Uganda. *Weiss and Keep (2013)* also states that localization involves adapting content to fit local cultural needs, where the adaption can include meeting local logistical constraints which affect access to information.

Fault diagnosis through expert system has received a lot of attention in the textile and garment industry over the last years. We found several studies that are able to automate the diagnosis process of textiles with expert system *(Weldeslasie, Dawit Teklu, et al., 2019).* Some of them are reviewed as the following:

Song (1992) describes a prototype expert system

- for yarn spinning process planning in textile industry. Unfortunately, its performance is not measured at all. What *Song (1992)* does focus is "on yarn process planning".
- ***Hussain and Shamey (2005)*** designed and developed an expert system for diagnosing problems in the dyeing of cotton. But, the researchers do not implement effective approach for implementing multiple experts' opinions or sorting experts' responses.
- ***Dlodlo et al. (2007)*** describes hybrid expert system architecture to support yarn fault diagnosis. But, this architecture is neither evaluated by a developed prototype system nor studied at textile and garment industries.

Thus, from the three literature reviews above, international researches encourage textile and garment manufacturing towards implementing expert systems.

In additions to the above studies, several studies were also conducted locally on expert system in order to support reasoning and finding solutions for certain problems (see Table1). As a result, series of problems that deals with ICT, health etc has been addressed with expert system researches. Unfortunately, apart from the mentioned fields above, defects on textiles and garment industries has not been given due attention. As a result, the textile and garment sector is a missing research.

In addition, majority of the studies conducted locally on expert system are implemented in English language. It is true that English language cannot be used by the majority of the population, either because it does not treat matters that are relevant for that specific population or because it is in a language that specific population does not understand in Ethiopia.

Table 1 Summary of Locally Related Works on Expert System Research

No	Author	Title	Sector	Research Methodology	Language Support
1	Tagel (2013)	Knowledge based system for pre-medical triage treatment at Adama University Asella hospital	Health	Literature review, data collection, purposive sampling, production rules and evaluation	English
2	Solomon (2013)	A self-learning knowledge based system for diagnosis and treatment of diabetes	Health	Literature review, data collection, purposive sampling, production rules and evaluation	English
3	Amanuel (2014)	Developing an expert system for computer and network troubleshooting.	ICT	Literature review, data collection, purposive sampling, production rules and evaluation	English
4	Adane (2016)	Localized Knowledge based System for Human Disease Diagnosis	Health	Literature review, data collection, purposive sampling, production rules and evaluation	Amharic

1. DESIGN APPROACHES

The following diagram shows our research frame work applied in the study (see Figure 1 below).

I. Textile and Garment Industry

Our research environment is textile and garment industry. It is composed of employees, textile and garment industries, and their existing technologies. Thus, an assessment result of the environment during manufacturing is well studied.

II. Identify Business Needs

Business needs of the industries are assessed and identified within the context of culture and existing processes in order to be supported by expert system technology.

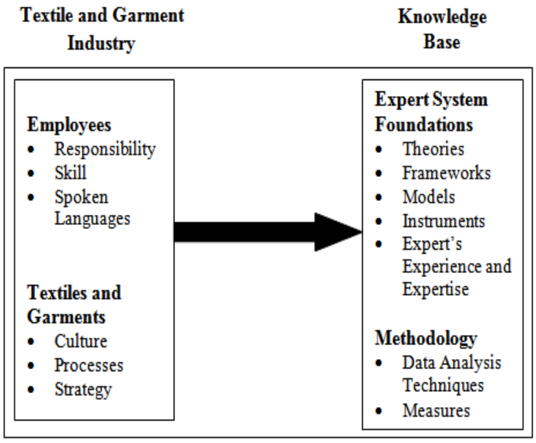

Figure 1 the Research Framework

III. Knowledge Bases

The foundations of the research are acquired from existing theories, frameworks, models, instruments, experience and expertise of domain experts. This is done through literature review, survey questionnaires, expert's interviews and physical observation.***Sample Size***

ALTEX and MAA Garment and Textiles, taking these few number of industries into account both are selected for our study sample in Ethiopia. The number of workers to be included in the study was determined using single population proportion formula adapted from *Bethlehem (2010).* Hence, the formula for our study sample is shown below.

$n = (Z\alpha/2)^2\ p\ (1-p)/d^2$

Where, $(Z\alpha/2)$ = Reliability coefficient = 0.7

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n = Sample size.

p = 15%, taking the assumption that 85% of the workers had low level of skill and knowledge of yarn fault diagnosis and rectification.

d = assumed marginal error (5%).

$n = (0.7)^2 (0.15) (0.85)/ (0.05)^2$ =**25**

Hence, from the above computation 25 individuals were contacted for the survey. Simple random sampling was used to select the individuals. But, to achieve pertinent information, certain inclusion criteria were imposed. The participants include operators, technicians and managers from yarn spinning department. Moreover, a total of 13 respondents were selected from ALTEX and 12 respondents from MAA Garment and Textiles. Thus, 25 questionnaires were distributed among these all (100%) questionnaires were collected and correctly completed.

III. ANALYSIS, FINDING AND DISCUSSIONS

The analysis techniques used in this study are minimum, maximum, percentage, mean and standard deviation. Minimum was used to explore the minimum of respondents. Maximum percentage was used to explore the maximum of respondents. The mean was used to see the average responses of respondents for each questionnaire. Similarly, the standard deviation measures how widely values of responses are dispersed from the mean value.

There are three parts of questionnaires (Part ‘A’, Part’ B’ and Part ‘C’). Accordingly, the researchers analyzed each part as the following:

i. Part ‘A’ Questionnaire

This part contains 5 questions. Thus, Operators, technicians and managers were asked to fill their job title, experience, educational level, language speak and their computer skills in using local language applications. For clarification each question has been analyzed sequentially as follows.

Q1: What is your educational Level?

The scales used in these question are; 1 = Diploma or below, 2 = 1st Degree and 3 = 2nd Degree. Table 2 shows that 72 % (the highest percentage from others) of the workers were diploma or below, 24 % with 1st degree and 4% with 2nd degree.

Table 2 Frequency Showing Educational Level of Employees

What is your educational Level?		
Educational Level	**Frequency**	**Percent**
Diploma/below	18	72%
1st Degree	6	24%
2nd Degree	1	4%
Total	**25**	**100%**

The researchers are aware that the value and importance of qualified professional is considerable. However, the result of table 2 shown above indicates that the education level of the workers is dominated by diploma/below with 72%. This result indicates there is luck of highly educated personnel to effectively understand the theoretical and practical concept of textile faults. It is also common and logical that less educational status make difficult in the development and transfer of technology process.

Therefore, the educational level of employees in these textile and garment industries is poor as a result of low educational status.

Q2: What is your job experience?

This is an open question. So, employees are allowed to write their job experience on the space provided. As a result, table 3 shows the minimum job experience is 1 (one) year and the maximum job experience is 12 (twelve) years. The mean value (5.12) tells us that majority of the employees have about 5 years working experience. The results also shows that the standard deviation value is reasonably high (2.877), indicating the average respondents do have big difference of experience among them. Therefore, we conclude these employees cannot be said professionally competent. Consequently, this can be a reason for low performance observed from these textile and garment industries.

Table 3 Job Experience of Employees

Descriptive Statistics					
Question	**No of Workers**	**Minimum**	**Maximum**	**Mean**	**Standard Deviation**
What is your job experience?	25	1	12	5.12	2.877

Q3: What is your job title?

The scales used in these question are; 1 = Operator, 2 = Technician and 3 = Manager. Table 4 shows that 76% (the highest percentage from others) of the workers were operators, 20% technicians and 4% Managers.

Table 4 Frequency and Percent of Operators, Technicians and Managers

What is your job title?		
Task Force	**Frequency**	**Percent**
Operator	19	76%
Technician	5	20%
Manager	1	4%
Total	**25**	**100%**

As we can see from table 4 above, majority of the task force (about 76%) in the industry are operators which are said to have low skill than technicians and managers.

However, they can be trainable and productive when they get assistance via technology transfer like by implementing expert system. Therefore, it is advisable providing of training to operators based on their skill gap to reach the level of skill owned by technicians and managers.

Q4: What is the easiest language for you to communicate with your collogues at work?

The scales used in these question are; 1 = Tigrigna, 2 = Amharic and 3 = English. Table 5 below shows that 84% (the highest percentage from others) of the workers communicate in Tigrigna, 10% in Amharic and 5% in English.

Table 5 Frequency and Percent of Regularly Spoken Languages at Industry

What is the easiest language for you to communicate with your collogues at work?		
Language	**Frequency**	**Percent**
Tigrigna	21	84%
Amharic	3	12%
English	1	4%
Total	**25**	**100%**

Table 5 above indicates that Tigrigna, Amharic and English languages are spoken in the textile and garment industries of Tigray, Ethiopia. Therefore, all languages shall enjoy equally and should all be treated equally. We understand that the study should meet local constraints and access of technology should be in the language of own workers. Therefore, these local language constraints are important to the industries that need to be solved by expert system.

Q5: What is your computer skill to use applications written in your language?

The scales used in this question are; 1 = High, 2 = Medium and 3 = low. Table 6 shows that 44% (the highest percentage from others) of the workers has high skill of using applications written in their native languages, 44 % with Medium and 10% with low skills.

Table 6 Frequency and Percent of Computer Applications Skill

What is your computer skill to use applications written in your language?		
Skill	**Frequency**	**Percent**
High	11	44%
Medium	11	44%
Low	3	12%
Total	**25**	**100%**

The skill of workers on utilizing computer applications is among the important factors for the successful introduction of expert system into the diagnosis and rectification of textile faults. Accordingly, table 6 above shows that there is a significant positive usage of applications developed in their native languages with aggregate result of 88% high and medium usage of applications. Therefore, there is no problem of using local applications, which we can conclude localization can be exercised in the prototype system of the research.

ii. Part 'B' Questionnaire

This part contains 8 statements. Experts, managers and technicians were asked to indicate their degree of agreement in an ordered rating on the challenges to yarn fault diagnosis and rectification in their respected industry. Accordingly, we used the Likert's rating scale method, which is very popular in assessing people's attitude. The graph in figure 2 below shows percentage of the identified challenges to textile fault diagnosis and rectification.

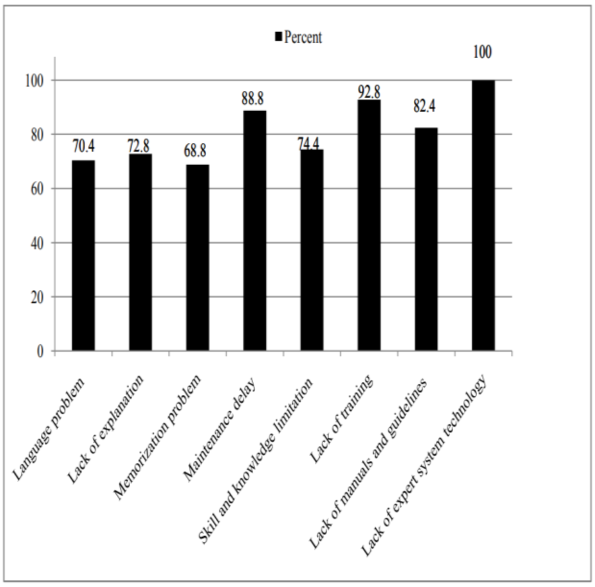

Figure 2 "The Identified Challenges" to Textile and Garment Industries of Ethiopia

So, the existing challenges of Textile and Garment Industries of Ethiopia have been assessed in the respected industries as shown in figure 2, and the raw data is shown in table 7 below. The assigned value of each score is 1 = Strongly Disagree, 2 = Disagree, 3 = Fair, 4 = Agree and 5 = Strongly Agree.

iii. Existing Challenges of the Industry

Ch 1: Language is a problem for you to interpret and understand the work environment.

Ch2: There is lack of explanation of faults and their causes given to inexperienced workers.

Ch3: There is a problem of remembering previous faults.

Ch4: There is delay during fault diagnosis and rectification.

Ch5: There is a skill and knowledge limitation to proper diagnosis and rectification of faults.

Ch6: There is lack of training about fault diagnosis and rectification.

Ch7: There is lack of maintenance manuals and guidelines about fault diagnosis and rectification.

Ch8: There is "No" software implemented yet in your industry that assists workers during fault diagnosis and rectification.

Table 7 Existing Challenges for Textile and Garment Faults

Existing Challenges	Strongly Disagree	Disagree	Fair	Agree	Strongly Agree	Mean
Ch 1	0	0	12	13	0	3.52
Ch 2	0	0	10	14	1	3.64
Ch 3	0	0	14	11	0	3.44
Ch 4	0	0	0	14	11	4.44
Ch 5	0	0	9	14	2	3.72
Ch 6	0	0	1	7	17	4.64
Ch 7	0	0	0	22	3	4.12
Ch 8	0	0	0	0	25	5
Total Avg.	**0%**	**0%**	**23%**	**47.5%**	**29.5%**	**4.065**

The result in *table 7* above shows that highest percentage (81.3%) of workers agreed that these challenges exist. The mean value (4.065) indicates that workers agreed these are the challenges for diagnosis and rectification of textile faults.

In addition, the culture of the textile and garment community in utilizing information technology for diagnosis and rectification of faults is not yet practical. We confirm that the research gap stated in our literature review is true and similar with our findings. Therefore, these problems should be solved by expert system research. Next, we perform reliability analysis as follows.

Table 8 Reliability Statistics for Existing Challenges Found at the Industry

Reliability Statistics	
Cronbach's Alpha	N of Items
0.708	**8**

From table 8 above we can see that Cronbach's alpha is 0.708, which indicates a high level of internal consistency of our scale and the raw data. So, since our reliability coefficient is higher than 0.70, then the data is considered as ‘acceptable’ in our research.

iv. Part ‘C’ Questionnaire

The general attitudes of the employees of the companies towards need of the prototype system development have been assessed. This part contains 8 statements.

Table 9 Reliability Statistics of Employees towards the Prototype System

Reliability Statistics	
Cronbach's Alpha	N of Items
0.713	**8**

From reliability statistics of table 9 shown above we can see that Cronbach's alpha is 0.713, which indicates a high level of internal consistency of our scale and the raw data, so as ‘acceptable’ in our research situation. Similarly, table 10 below shows views of employees on the prototype system development.

v. PROTOTYPE SYSTEM REQUIREMENTS

PSR 1: The prototype system should be developed in your own language for the sake of simplicity and understanding.

PSR 2: The prototype system should explain the faults, causes and their solutions using text and images.

PSR 3: The prototype system shall able to remember pervious textile faults.

PSR 4: The prototype system should save diagnosis and rectification time.

PSR 5: The prototype system should incorporate self-paced learning and training.

PSR 6: The prototype system should be accurate during diagnosis and rectification.

PTR 7: The prototype system should contain sufficient knowledge of diagnosis and rectifications of textile faults.

PSR 8: The prototype system should have contribution to diagnosis and rectifications of textile faults.

Table 10 Views of Employees for the Prototype System Development

Prototype System Requirements	Strongly Disagree	Disagree	Fair	Agree	Strongly Agree	Mean	Percent
PSR 1	0	0	0	5	20	4.8	96%
PSR 2	0	0	2	16	7	4.2	84%
PSR 3	0	0	1	7	17	4.64	92.80%
PSR 4	0	0	0	8	17	4.68	93.60%
PSR 5	0	0	0	10	15	4.6	92%
PSR 6	0	0	2	20	3	4.04	80.80%
PSR 7	0	0	1	14	10	4.52	90.40%
PSR 8	0	0	1	14	10	4.36	87.20%
Total Average	**0%**	**0%**	**3.50%**	**47%**	**49.50%**	**4.48**	**89.60%**

As shown in *table 10* above operators, technicians and managers were asked to indicate their degree of agreement to the design and development of textile and garment fault diagnosis and rectification expert system. The researchers used the Liker’s rating scale method. The assigned values of each score is 1 = Strongly Disagree, 2 = Disagree, 3 = Fair, 4 = Agree and 5 = Strongly Agree. The result in table 3.9 above shows that highest percentage (91%) of workers agreed that the prototype should realize all the requirements listed in the questionnaire.

This mean, a prototype system which considers employees needs should be constructed. Therefore, the result of this questionnaire becomes an input for the prototype system to be development.

IV. CONCLUSIONS AND RECOMMENDATION

Education and training for employees of textile and garment industries is very essential and should get attention. In both textile and garment industries majority of the employees have diploma or below educational status.

However, a key to item quality upgrading is education and training, which involves necessary knowledge and skills as well as influencing attitudes. So, the educational level of employees in these industries should be improved.

We have also assessed the training programs of both textile and garment industries. As a result, the textile and garment companies have limited training programs. Therefore, in these textile and garment industries, specific training on textile and garment fault diagnosis and rectification is required. We can conclude that there is maintenance delay that remains a problem for textile and garment industries because of luck of skill and training.

Some of tangible problems of the textile and garment industry found are also insufficient maintenance manuals and guidelines. In addition, we make sure that textile and garment industries in Ethiopia are not using computerized systems to assist their work during textile and garment fault diagnosis and rectification. Likewise, both textile and garment industries are characterized by a large population of limited skill manpower. Therefore, both the literature review and the results of our data analysis tell us that an expert system has not been applied yet Ethiopian textile and garment industries.

Moreover, the views of workers on the introduction of expert system into the diagnosis and rectification of yarn faults is included to evaluate the tendency of the textile and garment community. The results show that majority of the industry workers agreed on the introduction of expert system into the diagnosis and rectification of yarn faults. They agreed that the prototype system should be localized to fit their linguistic needs, which includes the access to the prototype system in their language.

As similar to the literatures say, the findings of this study also confirm the fact that the identified challenges to textile and garment industries are language problem, lack of explanation, memorization problem, maintenance delay, limitation of skill and knowledge, lack of training, lack of maintenance manuals and guidelines and lack of available technology which assists in fault detection. Hence, both the findings of our data analysis and literatures lead to design solutions of these problems.

Therefore, the needs assessment to the application of expert systems in manufacturing sector is satisfactorily assessed in this research work.

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