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Adaptive Learning and Thinking Style to Improve E-Learning System Using Neural Network 'ALTENN'

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M.Sc. in Engineering

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Declaration

I declare that this thesis which I now submit for the examination for the award of M.Sc. in Engineering is entirely my own work and has not been submitted in whole or part for an award in any other university or institute.

This thesis was prepared according to the regulations for postgraduate study of the Libyan Academy.

Ambarka Ali Elghali

Dedication

I dedicate this work to my father, mother, my family, for their never ending love, support, and encouragement, And to my teachers and friends.

Acknowledgements

My heartfelt thanks go to my parents, and all my family for their encouragement, and patience throughout my study.

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Abstract

In recent years the adaptive e-learning system has become of an increasing interest worldwide due to its benefits delivered to the learning system. This has been mainly driven by the realization of the idea of individualized learning (learning associated with the specific requirements and preferences of the individual) which cannot be achieved particularly at a massive scale using traditional approaches. In e-learning when the learning style of the student is not compatible with the teaching style of the teacher, difficulties in academic achievement can result. Therefore, knowing the preferred learning style supported by thinking style for individual can help in teaching and learning process. This research presents an adaptive e-learning system called **ALTENN** to improve e-learning environment. Neural network technology has been used to implement the model and identify the appropriate learning style based on the learner thinking style. The structure of the system, neural network (NN) implementation and results are presented in this research.

الملخص

في السنوات الأخيرة أصبح نظام التعلم الإلكتروني المبني على التكيف يلاقي اهتماماً متزايداً في جميع أنحاء العالم لما له من فوائد في تحسين نظام التعلم. ويعود ذلك بشكل رئيسي عن طريق تحقيق فكرة التعلم الفردي (التعلم المرتبط بمتطلبات المتعلم وما يفضلها)، والتي لا يمكن تحقيقها على نطاق واسع باستخدام أساليب التعلم التقليدية.

ففي التعلم الإلكتروني عندما يكون أسلوب التعلم للطالب غير متوافق مع أسلوب تدريس المعلم، تنتج صعوبات في التحصيل الدراسي. لذلك، يمكن أن تساعد معرفة أسلوب التعلم المفضل المعتمد على نمط التفكير للمتعلم في عملية التعليم والتعلم.

قدم هذا البحث نظام تعلم إلكتروني مبني على التكيف يسمى (ALTENN)، بغرض تحسين بيئة التعلم الإلكتروني. وقد تم استخدام تقنية الشبكات العصبية لتطبيق النموذج المقترح، ولتحديد أسلوب التعلم المناسب استناداً على أسلوب التفكير للمتعلم. وقد تم عرض أهم النتائج التي تم التوصل إليها، بالإضافة إلى تركيبة النظام، وتطبيق الشبكة العصبية (NN).

Chapter One

Introduction

1.1 Research Background and Motivation

Adaptive learning is defined as an educational method which uses computers as interactive teaching devices [1]. Computers adapt the presentation of educational material according to students learning needs. In a learning environment, each individual student has different requirements and characteristics. The important role of the educator is to recognize that their pedagogy and educational material must meet the learner characteristics and requirements. This is true for both traditional classroom approach and e-learning system. There is a need to move from one size approach that fits all to the personalized learning approach. Although there are many learning style approaches, theories, and methodologies that have been used for a long time in education, none of them have adequately covered all learning aspects such as personality, scale differences, and preferences. Many researchers have derived and used some elements from these models in an e-learning system but they were insufficient to overcome all e-Learning aspects such as learning preferences. The reason for this is that e-learning is unable to deal with individual learning and thinking style.

The most critical issue is that the learner is more independent in an e-learning system, whereas in traditional classroom a teacher can monitor and react accordingly based on student's response [2]. Therefore, e-learning system needs to be adapted to the learner's responses and presents information based on their preference. There are many techniques that have been used in e-learning system. To deal with adaptivity in different manners. Most of e-learning problems concern about four main issues such as: preferred learning style, course content presentation, intelligent tutoring system, and e-learning standards [2]. Adaptation has been defined as providing a different response based on different characteristics of the receivers of the response [3]. This research attempts to improve adaptive e-learning system by developing a system called **ALTENN** model. Neural network approach has been adapted to extract the most preferred learning style for each learner based on his/her learning types. A neural network consists of interconnected computational nodes, referred to as perceptions that map input attributes to one or more outputs [2]. Therefore, this model makes use of the advantages of the neural network to extract the learner style based on their thinking style.

1.2 Aims and Objectives

This research attempts to improve e-learning system by developing an adaptive e-learning system based on individual learning and thinking styles using neural networks technique. This can help students to gain knowledge by presenting the information in a different manner by analyzing their profile based on learner preference.

The research objectives are:

- To provide the required knowledge by analyzing learner's thinking style.
- To improve adaptive e-learning system by using neural networks to identify the preferred learning style based on the learner thinking style.

1.3 Research Questions

This thesis attempts to answer the following questions:

Q1- Does analyzing the learner profile based on thinking style and learning style help to improve e-learning environment?

Q2- Does the use of neural networks technique improve adaptive e-learning system based on learning and thinking style analysis?

1.4 Research Scope

In this research a system is developed to predict patterns of thinking, thus provides an appropriate type of learning style for each learner separately based on the pattern of thinking using neural network technology.

Weka is the tool that has been used to implement the research proposal. Weka is an open source software project composed of a collection of techniques such as machine learning algorithms for solving real-world problems and neural network. It contains tools for data pre-processing, classification, regression, clustering, association rules, and visualization. This tool can be accessed through a graphical user interface and through a JAVA API which makes the work environment suitable to implement the research.

1.5 Research Outline

Chapter 1: Introduction: presents research background and motivation, the research objectives, research questions, scope and research outline.

Chapter 2: E-learning Techniques and Models: this chapter introduces all the related work of e-learning background, e-learning style techniques, and e-learning thinking style.

Chapter 3: Learning and Thinking Style Model to Improve E-learning: this chapter presents the analysis of the research model.

Chapter 4: Adaptive E-learning Thinking Style Architecture Using NN and **ALTENN Implementation;** the architecture of neural network based on the research model is presented in this chapter.

Chapter 5: Validation and Verification: The proposed models are tested and all results such as survey results, neural network and system are presented.

Chapter 6: Conclusion and Future Work: this chapter is the conclusion, which presents summary, contributions, and future work.

Chapter Two

Theories Thinking and E-learning Techniques

2.1 E-learning

E-learning is the use of computer technology and multimedia devices to deliver educational content in order to facilitate access to educational content anywhere and at any time.

The aim of e-learning is to provide mobilization supported applications and multimedia that rely on computers and networks of online information. This enables the learner to access information and acquire knowledge at any time and in any place [6].

2.1.1 E-learning Advantages

1. Reduces time and cost of traveling from one place to another.
2. Learners can obtain the educational materials that meet the level of knowledge.
3. Learners can learn from anywhere and anytime through access of computer and Internet connection.
4. Flexibility to join the discussions and bulletin board, or communicate with colleagues and trainers in remote chat rooms.
5. Promotes more interaction between learners and instructors.
6. E-learning accommodates different learning styles, multimedia and facilitates learning through a variety of activities.
7. Builds self-knowledge and self-confidence as well as encourages learners to take responsibility for their own learning and acquiring knowledge [6], [7].

2.1.2 E-learning Disadvantages

1. Lack of dealing with face-to-face teaching and learning process.
2. Difficult to build course content that carries different learning styles.
3. Computers do not handle emotional aspects [6].

2.2 Adaptive E-learning System

Adaptive system becomes the main concern for many researchers to adapt the content for the user and to facilitate access in order to improve the learning and teaching process. The adaptive system is a system that is able to adapt its behavior according to changes in its environment [8].

2.2.1 Adaptive E-learning System Advantages

1. Fast and high quality for learning process.
3. Adapts different abilities.
5. Engages different learners.
6. Allows learners to work at different aspects.
7. Provides more interactive learning systems [9].

2.2.2 Adaptive Learning Cycle

Adaptive learning cycle can be divided into four components as:

1. Concept adopting through a selected learning model.
2. User takes diagnostic test.
3. Concept deficiencies and best learning model is identified.
4. Corrective course is dynamically created with an appropriate learning model [10].

2.3 Adaptive E-Learning Techniques

Many researchers attempted to find and develop adaptive e-learning systems and techniques to improve e-learning system. Such techniques are presented as follows:-

- **iWeaver:** This technique was designed to adapt learner based on Dunn model learning style technique to analyze learning patterns. The aim of iWeaver is to accommodate individual learning styles in the e-learning environment. The educational environment changes according to the change in the learner behavior [11]. The flowchart of the system is shown in Figure 2.1.

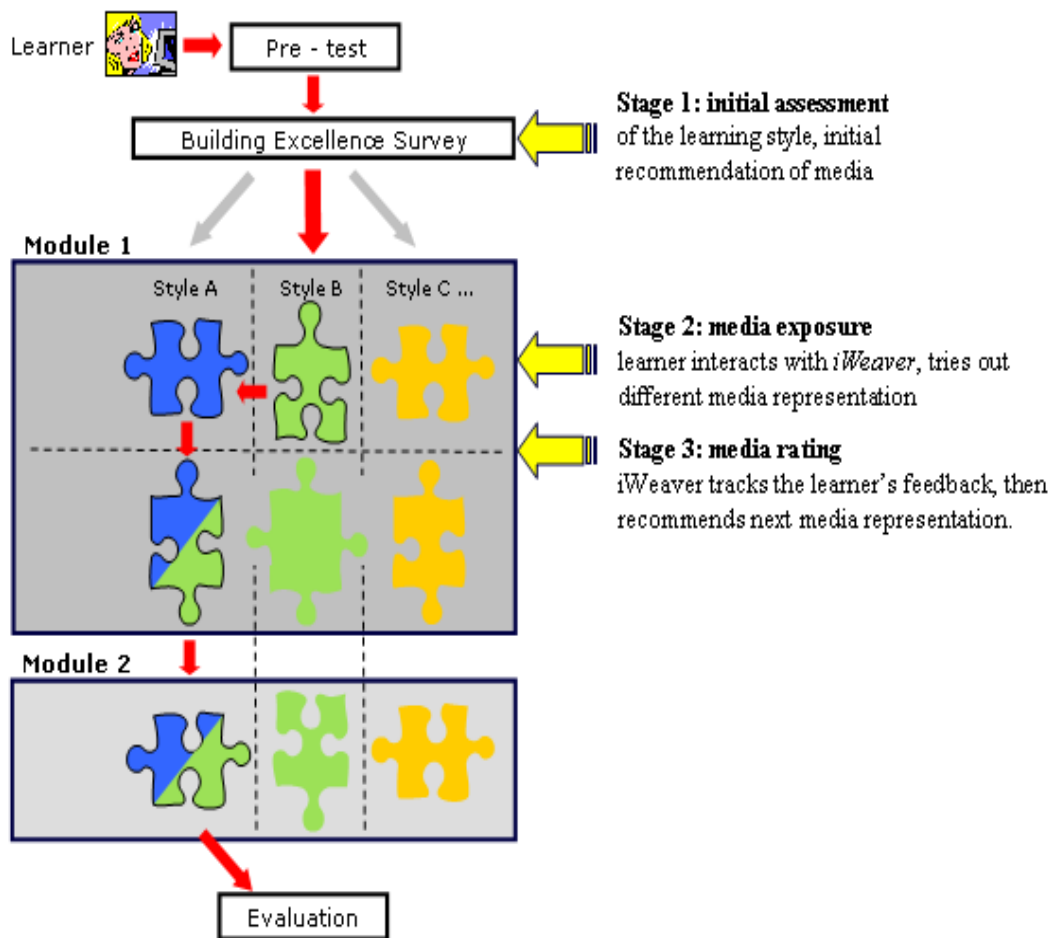


Figure 2.1: iWeaver Flowchart [11]

• Adaptive Courses in Learning Management Systems

This technique was added an additional function to LMS to provide scalability based on each learner to be adapted. This can be achieved through the analysis of the behavior and performance of students. It was observed that the students who learnt by their own style spent less time than normal time in the same course content [12].

This model is divided into three extensions:

1. Removing students' information which is extension1.
2. Annotating learning objects called extension2.
3. Presenting adaptive course is represented by extension3.

The extensions are shown in Figure 2.2.

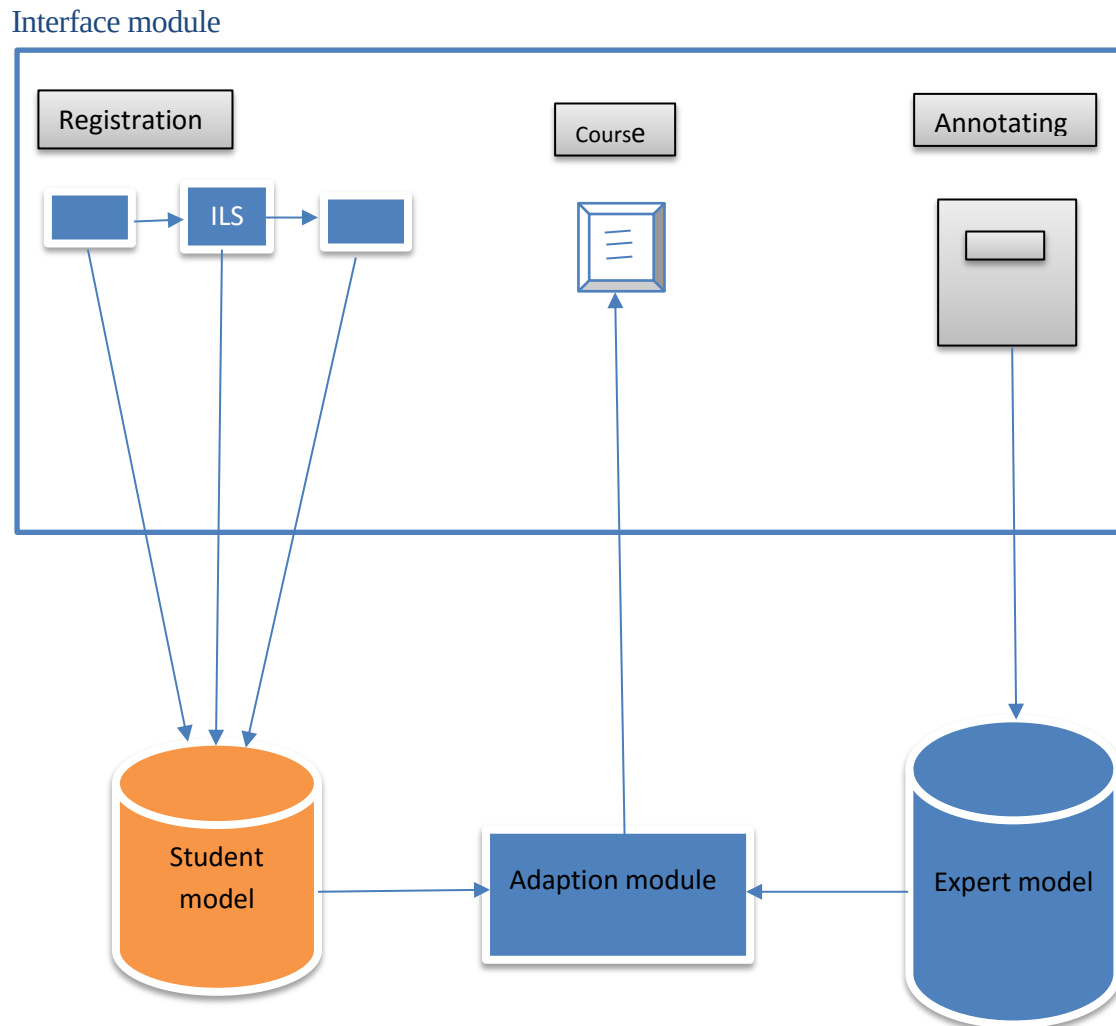


Figure 2.2: Extensions of the LMS architecture

- **Adaptive Personalized Course Learning System (APCL)**

This research used learning methods and results as criteria addressed the objective and the purpose of adaptive profile of learners and to provide an appropriate learning path taking into account the differences in individual learning systems. The APCL method was implemented to improve adaptive e-learning system and is shown in Figure 2.3 [13].

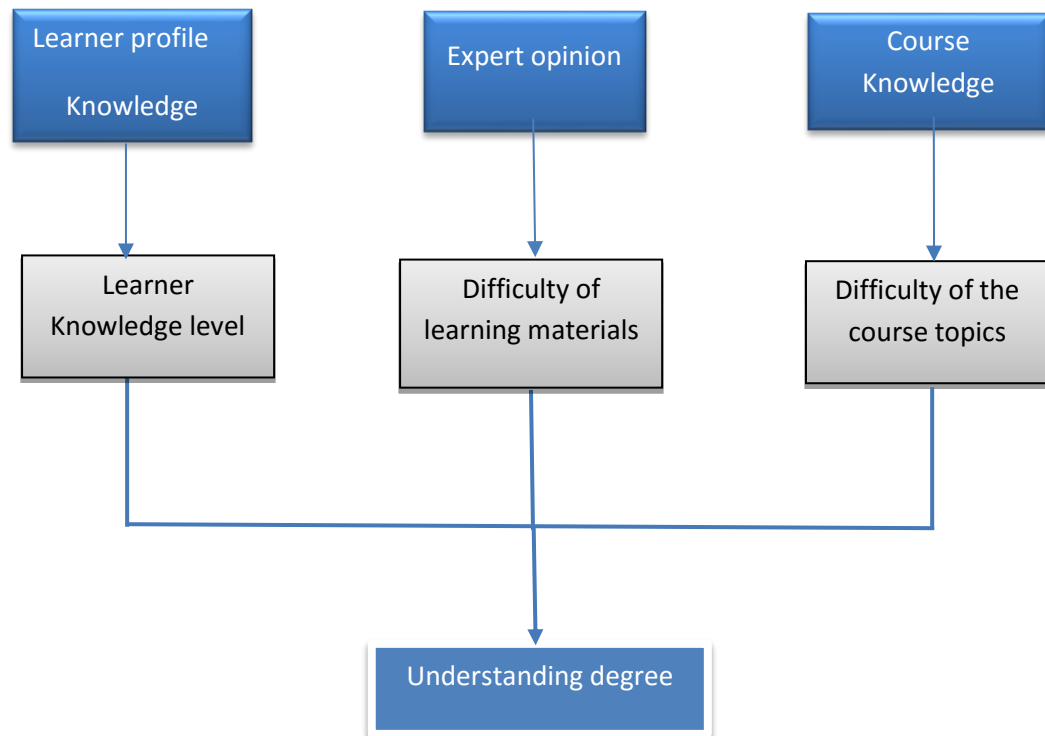


Figure2.3 APCL architecture

- **Adaptive E-learning Using Semantic Net**

This system was designed for tracking the learner's behavior by using IT-Semantic web technology, which tracks the learner behavior by examining their knowledge level. The semantic web approaches provide the basis of a recommendation system for e-learning through the use of tracking of behavior, testing and verification of the cognitive level [4].

- **Adaptive E-Learning System Using User Response Theory**

This research produces a framework to formulate adaptivity for adaptive e-learning system using user response theory. The main advantages of this framework are to provide a path for e-learning and to propose a framework to adapt the e-learning system using the user's response. This meets the objectives of the research characteristics of learners' inference systems theory, and identify learner's preferences, consequently generates personalized learning path and customizes the learning contents to meet the needs of individuals [14].

2.4 Thinking

Sternberg defined thinking as a mental cognitive process, which directly affects the process of information processing and mental representations of knowledge in the human mind [6].

2.4.1 Thinking Styles

Sternberg defined thinking styles as the individual preferred method of thinking, and describes how the individual uses that capacity exploits such as knowledge [6].

2.4.2 Theories and Methods of Thinking

Different theories of thinking patterns in different fields were reported, Sternberg–Wagner theory, Herman theory for Brain, Harison and Bramson thinking styles model. These theories and models are described as follows:

2.4.2.1 Sternberg –Wagner Theory

Sternberg defined way of thinking as the preferred way of thinking, which is not the ability, but it is an explanation of how to use our capabilities, and how to get advantage of them. People usually have different style of thinking which depends on their attitude. Based on Sternberg's theory these methods were divided into five components such as form, function, level, the trend and scope. These components include (13) style of thinking as shown Table 2.1 [6], [15].

Table 2.1: Thinking Style for Sternberg –Wagner Theory

Sternberg's theory	Types
Form	• monarchic style • hierarchic style • anarchic method • oligarchic style
Function	• legislative style • executive style • judicial style
Level	• global style • local style
The trend	• liberal style • conservative style
Scope	• external style • internal style

2.4.2.2 Herman Theory for Brain

Herman theory shown in Figure 2.4 classifies thinking styles into four types as follows:

1. Logical style: It is located in the upper left quarter and the symbol (**A**) is the most important characteristics of the ability to build a knowledge base, and the ability to understand the cognitive processes.
2. Organizational style: It is represented by the left lower quarter of the brain, and the symbol (**B**), and the most important characteristics of the organization of activities, and attention to detail.
3. The social style: It is located in the right lower quadrant and the symbol (**C**) is the most important characteristics of the ability to communicate and influence others.
4. Inventive style: It is located in the right upper quadrant, and the symbol (**D**) is the most important characteristics to search for alternatives, and obtain new ideas [16], [17].

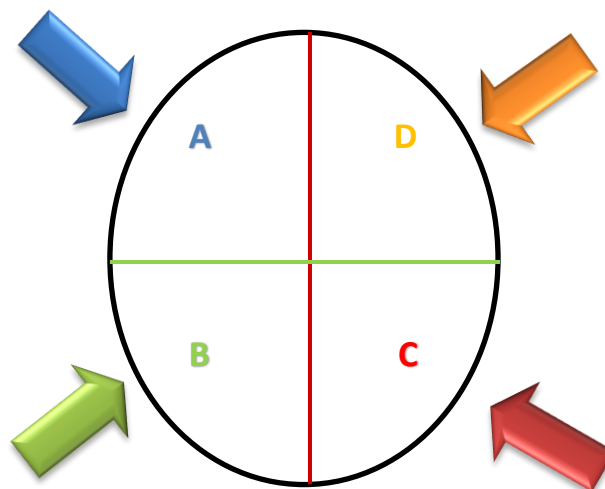


Figure 2.4 Herman Theory

2.4.2.3 Harison and Bramson Thinking Styles Model

Harison and Bramsonin 1982 suggested the existence of five methods favored by individuals which deal with the information available about style such as features of the problems and attitudes, and this classification based on the control of the brain (the left and the right) [18]. Each part has different pattern from the other in information processing performance by type (logical - illogical). The content of verbal - perception results in five basic thinking methods are:

- Synthetic.
- Pragmatic.
- Realistic.
- Idealistic.
- Analytic [18].

2.5 Learning Style

Learning style is defined as the way in which a person learns and acquires a knowledge or a skill [19].

There are many different learning styles models that researchers work with in education. Some of these models are described as the following:

2.5.1 VARK Learning Style Model

VARK learning style is used to acquire skills and knowledge, and reflect how people learn. This model is divided as (modalities of sensual visual, auditory, kinesthetic, read/write) as shown in Table 2.2[20].

Table 2.2: VARK learning style model

learning style	description
Visual	seeing and reading
Auditory	listening and speaking
Read/write	the written word
Kinesthetic	touching and doing

Visual (V):

Eyesight includes information in charts, diagrams and flow diagrams. People with a strong preference for visual learning like different shapes, space, charts, graphs, diagrams, maps and plans, as well as video, broadcast video and power point slides [19].

Aural / Auditory (A):

The sense of hearing is the process of listening, which includes audio tapes, and group discussion, e-mails, using mobile phones, talking and chatting on the internet. It includes talking loudly as well as talking to yourself. People with strong aural preference like discussions, stories, guest speakers and chat [19].

Read/Write (R/W):

This type of learning is to obtain information in the form of words. People with strong read/write preference like lists, notes, text either a soft or a hard copy, PowerPoint slides with audio, and multimedia [19].

Kinesthetic (K):

Touch / Kinesthetic people prefer learning through hands-on training, and physical exploration. People with strong kinesthetic preference in learning like senses, practical exercises, examples, cases, trial and error, multimedia interactivity and video [19].

2.5.2 Kolb Learning Style Model

In 1984 Kolb model introduced and explained the learning process on the basis of experiential learning theory [20]. Kolb learning cycle consists of four different stages of learning as shown in Figure 2.7 and as follows:

- Concrete Experience (CE).
- Reflective Observation (RO).
- Abstract Conceptualization (AC).
- Active Experimentation (AE).

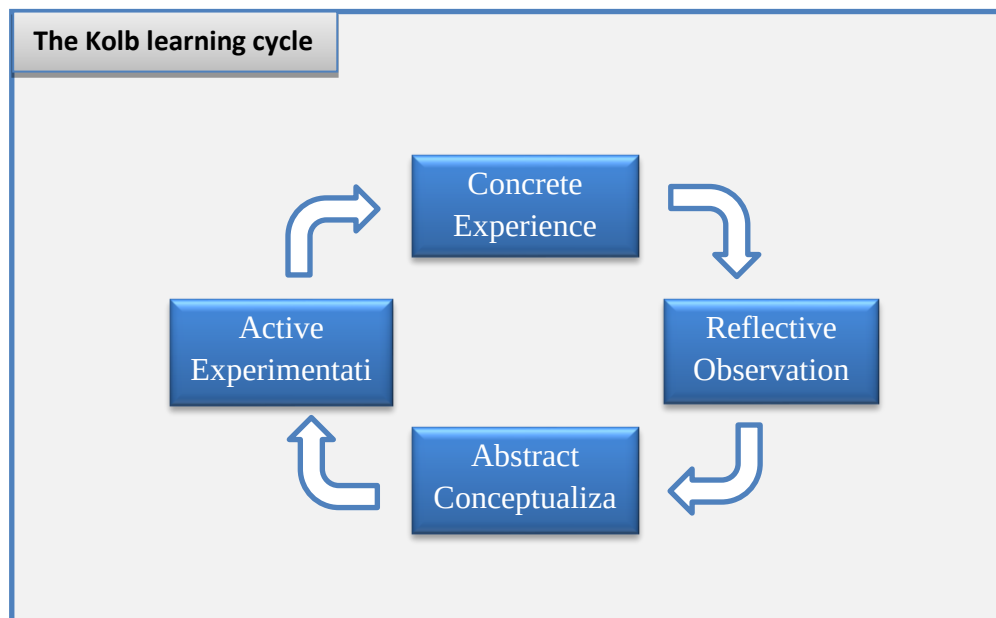


Figure 2.5: Kolb Learning Style Model

Kolb learning styles can be divided to four stages: diverging, assimilating, converging, and accommodating [20].

Diverging Style

These people are able to look at things from different perspectives. They have different learning styles and have wide cultural interests and concern to collect information. They prefer to work in groups to obtain feedback through a direct contact [21].

Assimilating style

This learning method is designed to accommodate the logical approach where ideas and concepts are more important. These people concern about understanding and obtaining information in a logical manner. People are more interested in ideas and concepts, and prefer readings, lectures, and explore the analytical models [21].

Converging Style

This learning method is based on problem solving and find practical solutions to the issues of style they prefer technical tasks and practical solutions to the ideas and theories, and make decisions through the creation of the ideas and solutions to problems [21].

Accommodating Style

This learning method is based on assimilation as "hands-on", which depends on intuition rather than logic and prefer to take the practical test approach. In this kind of learning style people explore a new experience and learning style that is relevant and is useful in situations where action and initiative are required. These people prefer to work in teams to complete tasks [21].

2.5.3 The Brain-Dominance Theory

The brain in this theory is divided into two sides. It is well known that both sides of the brain are involved in almost every human activity. Males have a tendency to be a right side dominant, while the left side dominant is for female [19]. The theory demonstrates the brain is shown in Table 2.3.

Table 2.3: Brain-Dominance Theory

Left brain (Analytic)	Right brain (Global)
1. Verbal	1. Visual
2. Responds to word meaning	2. Responds to tone of voice
3. Sequential	3. Random
4. Processes information linearly	4. Processes information in varied order
5. Responds to logic	5. Responds to emotion

2.6 Previous studies

The researchers have attempted to find techniques for adaptive e-learning system. They were concern about the interaction between the adaptive e-learning system techniques and artificial intelligence techniques. Senthil and Sankar [4] **suggested a** system for adaptive e-learning using semantic net. They used the system for tracking the learner's behavior using IT -semantic web technology, which tracks the learner behavior through testing and verifying of the knowledge level of the learner. The semantic web approaches provide the basis of a recommendation system for e-learning, through the use of tracking the behavior, testing and verification of the cognitive level of the learner. The learner profile is maintained as semantic net. The features of the content that the learner was preferred in the past can be stored in the learner's profile and used in the retrieval [4].

Lamia, Mohamed, and Philippe [5] designed and implemented an adaptive hypermedia model based on the thinking style. They used the hypermedia system to be adapted in education on the use of psychological criteria for thinking style. The model used a questionnaire HBDI to create a static model [5]. Figure 2.4 presents the system architecture.

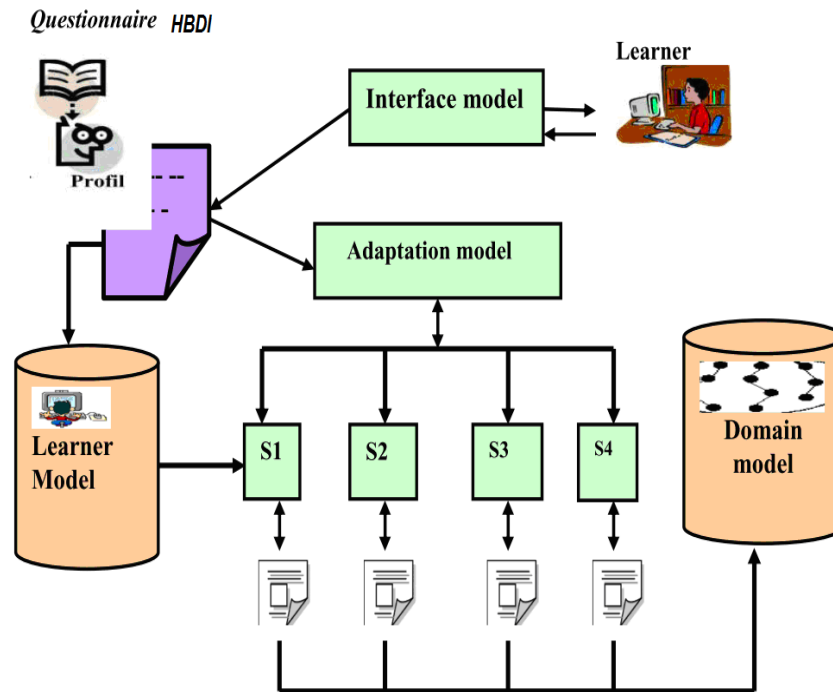


Figure 2.6: Adaptive Hypermedia Model Based on Thinking Style [5]

It is not possible to implement a complete system to cover different learning environments by considering only the adaptive audio systems using Hypermedia without taking into account the other learning environments, particularly Herrmann Brain Dominance Instrument (HBDI) to define the thinking styles without making changes or additions.

The research aims to study several theories of thinking styles. This can be conducted by a selection and examining of a set of theories and styles of learning. The research merges the characteristics of thinking styles selected with learning styles. A new model called **ALTENN** is proposed to improve the adaptive e-learning environment by defining the thinking style for each learner using a questionnaire. By defining the thinking style, the personal learner learning method can be identified using the neural network technology based on MLP algorithms in order to obtain accurate results.

Herman designed an adaptive e-learning system based on student's learning styles. He used the adaptability system based on two learning style models of VAK and Felder. Learning styles of VAK are audio, visual and kinesthetic learning styles, while they are global and sequential for Felder. A basis used in deciding to follow a particular learning mode is the highest score obtained in each group of learning styles. The system extends the advantages of conventional e-learning which are classroom and platform independence [1].

Vatcharaporn proposed a system that includes the major adaptive features based on a student model. The proposed system was able to initialize the student model for determining the knowledge level of a student when the student registers for the course. After a student starts learning the lessons and doing many activities, the system can track information of the student until he/she takes a test. The student's knowledge level, based on the test scores, is updated into the system for use in the adaptation process, which combines the student model with the domain model in order to deliver suitable course contents to the students [2].

This study used traditional approaches of e-learning. The principal of the study was based on student evaluation during their course by making exams, accordingly the student style was identified. This approach is traditional to identify the appropriate learning style for each learner. Therefore, the current research does not agree with this study.

Robert. Developed a model for the adaptive intelligent personalized learning environment (AIPL). The creation of a prototype implementation of a system designed for this model and the construction of a group of intelligent algorithms (Personalized Adaptive Filtering System- PAFS) for personalized learning were presented and evaluated. A mixed methods approach was used in the evaluation of the AIPL environment. The AIPL model was constructed on the principle of an ideal system being one which does not just consider the individual but also considers grouping of individuals with similar thinking and their power to influence the learner choice [1].

2.7 Neural network techniques

It is an attempt to simulate the biological composition of nerve cell of the brain to deal with any idea that the neural network is derived from the structure of the brain works. Neural network is useful to solve problems that cannot be expressed in the form of a series of steps such as pattern recognition, prediction and classification. The multilayer perceptron (MLP) represents the most outstanding and well researched class of ANNs in classification, and implementing a feed forward [22].

Neural network works to address the problems through specific steps and programmed and instruction through algorithms. The neural network based on biological foundations are

characterized by a neural network tradition of the work of brain nerves. It consists of several layers, input layer, output layer, and hidden layer.

Types of neural network algorithms:

1. The perceptron.
2. Feed forward neural network.
3. Kohnan self-learning networks [22].

2.8 Summary

Many researches have been carried out to improve e-learning adaptive system using different techniques. However, e-learning adaptive system still lacks the ability to provide more aspects such as psychological aspects and preferences which are difficult to be identified or measured accurately, or active participation. Learning style refers to how a learner interacts with, and responds to the learning environment. Different thinking methods have been used to determine students' learning styles. These theories and models were developed to describe and identify individual learning style in face to face environment. Adaptive learning has become the solution, and there is a necessity to deal with these systems which are different from the way of a traditional classroom. E-learning system must be capable of adapting the learners to ensure success. Therefore, it is important to improve and develop an adequate system to deal with thinking based learning through the prediction using neural network thinking and through thinking patterns. Consequently, describing patterns in an appropriate manner for each learner in their environment is possible. This will be reviewed and discussed in detail in chapter three.

Chapter Three

Learning and Thinking Style Models Analysis

3.1 Analysis of Learning and Thinking Style Models

There are many scientific theories of models of thinking and learning to support learning and teaching process. The learner in e-learning is different in which the learner needs to learn alone and separated from the traditional learning and teaching system, where the learner may face difficulties during the eLearning process. There are many researchers who attempted to improve adaptivity in the e-learning system, however a sufficient work is necessary to deal with differences and preference. Many researchers have used learning style model to improve the e-learning process, however thinking style has not been taken into account. This research proposed that the learning and teaching process based on individual thinking style can assist learners to accommodate the new learning approach based on their preferred learning style.

This research analyzed different learning models and thinking theories to develop the research model. The models and related analysis are presented in this chapter and the following models are chosen to develop the research model: as shown in Table 3.1.

Table 3.1: Learning and Thinking Style Models

Thinking Style	Learning Style
• Sternberg and Wagner theory of thinking style.	• Kolb learning style model.
• Harison and Bramson thinking styles model.	• VARK learning style model.
• Herman theory of brain of thinking style.	• The brain-dominance theory.

3.2 Characteristics of Thinking Styles

This research attempts to develop a model that can be used to identify the preferred learning style model for learners based on their personal thinking style. As a result the characteristics of thinking and learning method need to be identified as shown in Tables 3.2, 3.3. The characteristics of thinking and learning styles were chosen based on the compatibility and the proximity to the theory of the brain (right brain and left brain). Each of them differs from others in information processing such as logical and illogical performance. Table 3.2 presents various theories and methods associated with types of their thinking style [6], [16], [17]. The descriptions of thinking style characteristics are presented in Table 3.3[18], [19], and [20].

Table.3.2: Theories and methods of thinking

Theories and methods of thinking	Types of thinking styles
Sternberg's theory	• Form: monarchic style, hierarchic style, anarchic method, oligarchic style. • Function: legislative style, executive style, and judicial style. • Level: global style, local style. • The trend: liberal style, conservative style. • Scope: external style, internal style.
Herman theory for Brain	• Logical style. • Organizational style. • Social style. • Inventive style.
Harison and Bramson thinking styles model	• Logical– illogical: Synthetic, pragmatic, realistic, idealistic, analytic.

Table.3.3: Analysis of results of thinking styles characteristics

Thinking Styles	Characteristics
Analytical Style	This method is characterized by the owners of planning and rationality and theorizing, accuracy and conclusion, perseverance and gathering information with a holistic view of the composition, and the face of the problems carefully and methods of systematic attention to detail and his ability to predict, cares about research and audit, advice and guidance. And characterized by the ability to interpretation, analysis and summary and link their theoretical ideas experiences of everyday life, and they have serious concerns about the study.
Pragmatic Style	This method is characterized by adventure and preference of the experiment and search for a quick solution and attention to the procedural aspects of the work, as well as to initiate a new solution.
Local style	People characterized by this method focus on fine details of the issues, and they tend to be logic and prefer the sequence in dealing with issues.
Global Style	This type of thinking style is characterized by focusing on the public interest in the form of questions and details, dealing with random. Questions and concern about the finalization of shapes and images to clarify issues.

3.3 Analysis of Characteristics of Learning Style Models

Characteristics of VARK learning style model, Kolb learning style model and the brain-dominance theory were compared and analyzed. These learning style methods were discussed to identify which learning style characteristics are most adequate with the thinking styles and skills. The analyzed leaning style models are presented in Table 3.4.

Table 3.4: Characteristics of learning style models

Learning style Models	Characteristics			
VARK	Visual seeing and reading	Auditory listening and speaking	Kinesthetic Touching and doing	Read/write The written word
Kolb	Accommodating	Diverging	Converging	Assimilating
brain-dominance theory	Left brain (Analytic) Verbal		Right brain (Global) Visual	

3.4 Analysis of Thinking and Learning Style Models

An analysis to determine the characteristics of thinking style and which learning style is most appropriate was carried out. The following is the comparison of different models of learning and thinking styles characteristics.

3.4.1 Analysis of VARK Model and Thinking Style Characteristics

VARK learning style model can be described in four stages: Visual (V), Aural / Auditory (A), and Read/write (R/W) and kinesthetic (K) as shown in Table 3.3, and the characteristic of each element are analyzed and presented in in Table 3.5.

Table 3.5: Analysis of the characteristics of thinking and VARK model characteristics

VARK Learning Style	Analytical Style	Pragmatic Style	Local style	Global style
Visual (V)	✓			✓
Aural / Auditory (A)		✓	✓	
Read/write		✓	✓	
Kinesthetic (K)	✓			✓

3.4.2 Analysis of Kolb Model and Thinking style Characteristics

Kolb learning style is described in four stages: diverse, absorbing, and converge and accommodate as shown in Table 3.6.

Table 3.6 Analysis of thinking style characteristics with Kolb learning style model characteristics

Kolb Learning Style	Analytical Style	Pragmatic Style	Local style	Global style
Diverging (CE/RO)	✓			✓
Assimilating (AC/RO)				✓
Converging (AC/AE)		✓	✓	
Accommodating (CE/AE)		✓	✓	

3.4.3 Analysis of the brain-dominance theory and thinking style characteristics

The brain-dominance theory can be described in stages as: Left brain and Right brain as shown in Table 3.7 associated with thinking style.

Table 3.7 Analysis of the characteristics of thinking and brain-dominance theory characteristics

The brain-dominance theory	Analytical Style	Pragmatic Style	Local style	Global style
Left brain	✓	✓	✓	
Right brain				✓

3.5 Comparison Between Thinking style and Learning Style Characteristics

This comparison between thinking style characteristics and characteristics of e-learning style model discussed above is shown in Tables 3.8, 3.9.

Table 3.8: Comparison analysis of thinking style characteristics with learning Style models

Characteristics				
Learning style	Analytical Style	Pragmatic Style	Local style	Global style
Visual (V) and Diverging (CE/RO)	✓			✓
Aural (Auditory) (A)		✓	✓	
Assimilating (AC/RO), Right brain, Visual (V), and Kinesthetic (K)				✓
Converging (AC/AE), Accommodating (CE/AE) and Left brain, Read/write (R)		✓	✓	

3.6 Thinking and Learning Styles for E-learning Systems

Based on the above analysis and comparisons the research model has been defined and developed to define the most preferred learning style for each learner based on his/her own thinking style.

For example in Table 3.9, to determine the learner thinking pattern of type I (Analytical), it is appropriate to have a visual learning, such as video, Vodcast, and PowerPoint slides.

The research model system was extracted from the research of **Adaptive Learning and Thinking Style to Improve E-Learning Environment Using Neural Network**. To develop the adaptive e-learning system to identify the appropriate learning style for type I (Analytical), a visual learning style is appropriate as shown in Table 3.9.

Table 3.9: the research model

Thinking Style	Learning Style	E-learning Style Representation
 Type I: T1 Analytic Style	 Visual (V)	People with a strong visual preference for learning like: Different formats, space, graphs, charts, diagrams, maps and plans. Video , Vodcast , PP slides .
 Type II: T2 Pragmatic& Local style	 Aural (Auditory) (A)& Read/write (R)	People with a strong aural preference for learning like: Discussions, stories, guest speakers, chat. People with a strong read/write preference for learning like: Lists, notes and text in all its formats and whether in print or online. PP Slides with audio , Multimedia , Podcast , Text documents .
 Type III: T3 Global style	 Kinesthetic (K)& Visual (V)	People with a strong kinesthetic preference for learning like: Senses, practical exercises, examples, cases, trial and error. Multimedia interactivity , Video , PP slides .

To implement the proposed model the thinking style for an individual needs to be recognized. This has been formulated in form of a questionnaire contains (16) questions as shown in Table 3.10. Table 3.11 demonstrates the elements of the three types of the proposed model of thinking style.

Table 3.10: Extracting thinking style questionnaire

No	Questionnaire	T1	T2	T3
1	Do you have the ability to analyze and study problems?	✓		
2	Do you have a tendency to link theories to your own experiences in order to solve problems?	✓		
3	Do you have the ability to conduct researching and use projection to describe your ideas?	✓		
4	Do you have a tendency to create an accurate and broad-based view of the problem that you encounter?	✓		
5	Do you pay much attention to details when dealing with problems?	✓		
6	Do you seek guidance and advice to solve problems?	✓		
7	Do you have the ability to analyze the problem and make conclusions?	✓		
8	Do you like experimenting and taking gradual steps to solve practical problems?		✓	
9	Do you have the ability to come up with new methods to solve a problem?		✓	
10	Do you have a tendency to act at leisurely pace when dealing with problems?		✓	
11	Do you have a tendency to pay much attention to the little details of the problem?		✓	
12	Do you have a tendency to work on the physical part of the problem?		✓	
13	Do you like dealing with practical situations and doing experiments to solve problems?		✓	
14	Do you have a tendency to ignore details and manage the problem with an abstract attitude?			✓
15	Do you have a tendency to deal with problems generally?			✓
16	Do you have a tendency for recreation and visualizing the problem?			✓

This model has been formulated in the form of a questionnaire as shown in Table 3.11. For example, what is your thinking style in Analytic Style? The answer is Type I (**T1**)

Table 3.11: Determining of thinking style type

 Type I=T1	 Type II=T2	 Type III=T3
Analytic Style = Question (1-7)	Pragmatic style = Question (8-10) Local style = Question (11-13)	Global style = Question (14-16)

This search has proposed a system to predict patterns of thinking and provide an appropriate type of learning for each student or learner separately based on the pattern of thinking using neural network technology.

3.7 Summary

The aim of this research in this chapter was to examine a variety of methods of thinking styles such as that of Sternberg and Wagner (1997-2002), Harison and Bramson. The models were reviewed to study and learn the characteristics of the thinking patterns and compared with a variety of learning models such as the VARK, Kolb models and brain-dominance theory. It was to take advantages of examining of teaching models and characteristics of learning models mentioned above to improve the e-learning adaptive system. It was determined the thinking style of each learner individually associated with its knowledge of learning style. It was observed that the thinking style of the learner and it is educational content are consistent. This is taking into account the individual and sensual tendencies of the learner through the study and determine the model of thinking. This is very important to improve the e-learning adaptive which previously lacks to deal with face to face.

Chapter Four

Implementation of the **ALTENN** Model Using Neural
Network

4.1 Structure of ALTENN Model

ALTENN is the name of the system that was extracted from the research titled **A**daptive **L**earning and **T**hinking Style to Improve **E**-Learning System Using **N**eural **N**etwork.

Neural network technology has been used to implement the adaptive system to predict the learner's learning style based on his/her personal thinking style. The structure of the system has been developed as shown in Figure 4.1.

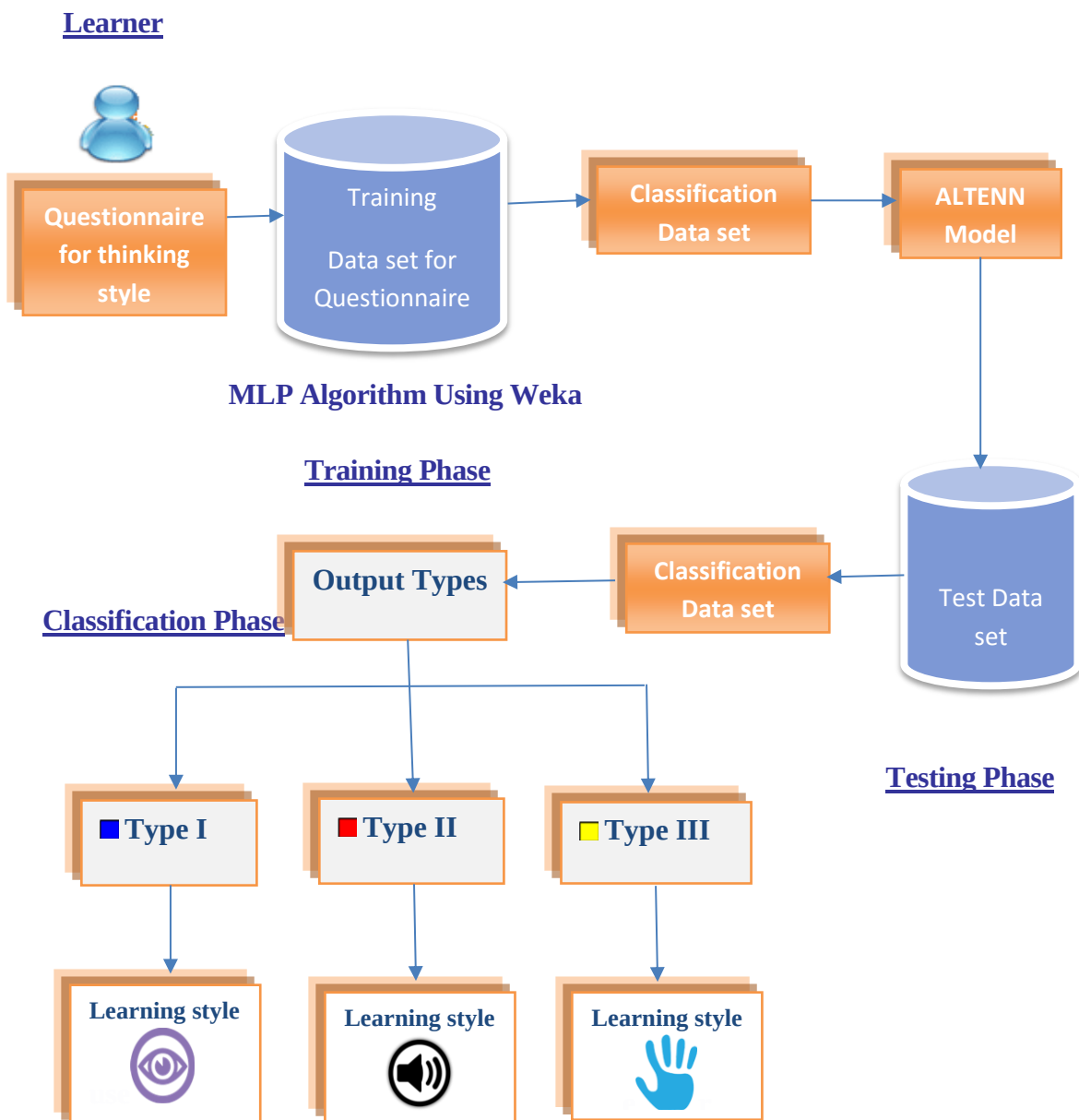


Figure 4.1 Overall Architecture of **ALTENN** Model

Step 1: Identifying the Learner Thinking Style Using NN

The learner begins the system by filling up the questionnaire which is the input of the intelligent neural network system to identify patterns of thinking style of the learner and to accommodate the preferred learning style as shown in Figure 4.2.

WHAT'S YOUR THINKING STYLE ?

Learning Styles Self-assessment ?

Everybody has a preferred learning style. Knowing and understanding our learning style helps us to learn more effectively. This is particularly true for people because of their different ways of learning. Through identifying your learning style, you will be able to capitalize on your strengths and improve your self-advocacy skills.

Score each statement in the columns below by giving yourself the appropriate number:

1 - Strongly disagree
2 - Disagree
3 - Average
4 - Agree
5 - Strongly agree

Click on the "Submit" button at the end of the questionnaire to see your result

1 - Do you have the ability to analyze and study problems ?
2 - Do you have a tendency to link theories to your own experiences in order to solve problems ?
3 - Do you have the ability to conduct research and use projection to describe your ideas ?
4 - Do you have a tendency to create an accurate and broad-based view of the problem that you encounter ?
5 - Do you pay much attention to details when dealing with problems ?
6 - Do you seek guidance and advice to solve problems ?
7 - Do you have the ability to analyze the problem and make conclusions ?

Figure 4.2 identifying the learner thinking style using NN

Step 2: Training Phase

The development process began with questioning of 20 students using face to face questionnaire to verify the model extracted for the learner's learning style based on their personal thinking style. The results showed that the model was approved to be successful with 85%. Then ALTENN system was tested using neural network technology using Multilayer perceptron's algorithm MLP.

Step 3: Testing Phase

The overview of the system architecture is presented in Figure 4.1, which consists of four main components, training phase using neural network, testing phase, and classification phase using ALTENN model. These components were developed as in the following sections:

Input and output

ALTENN uses NN presented in Figures 4.3, 4.4 which consists of (16) questions as input layer and three outputs.

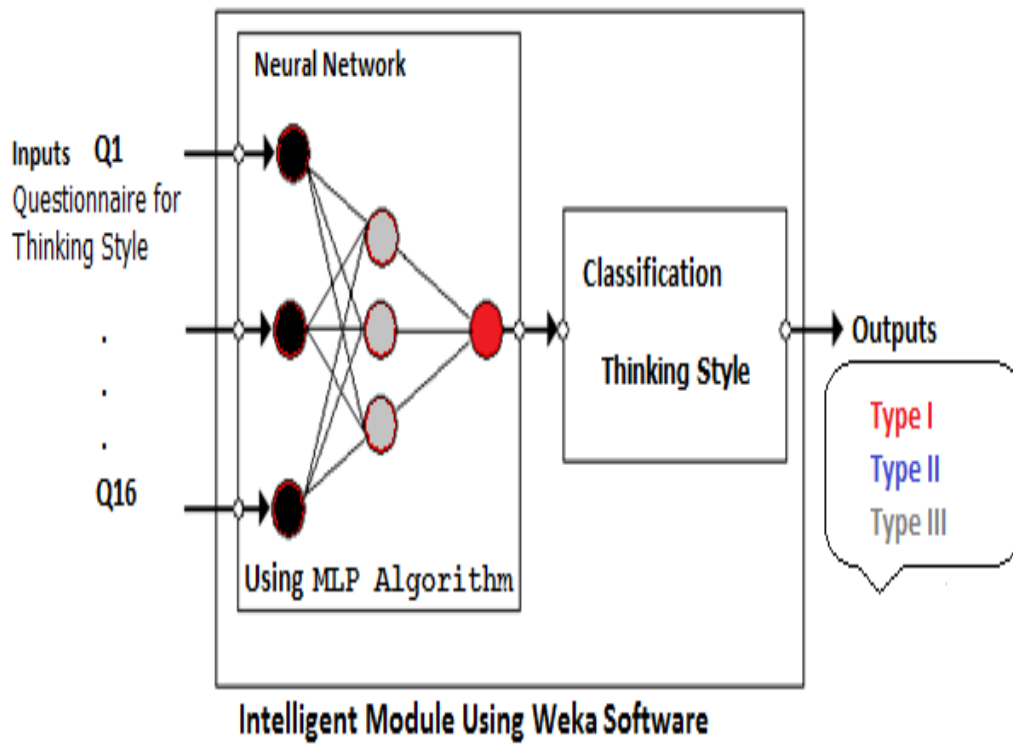


Figure 4.3: MLP using NN



Figure 4.4 Questionnaire using NN

The Input layer represents the input pattern to recognize the target approach through output layer. The thinking style model has converted into (0.0, 0.25, 0.5, 0.75, and 1.0) to suit neural network input as shown in Table 4.1.

The model was tested on a sample of (20) students and the results were positive and correct based on the Multilayer Perceptron's Algorithm (MLP) as shown in table 4.3.

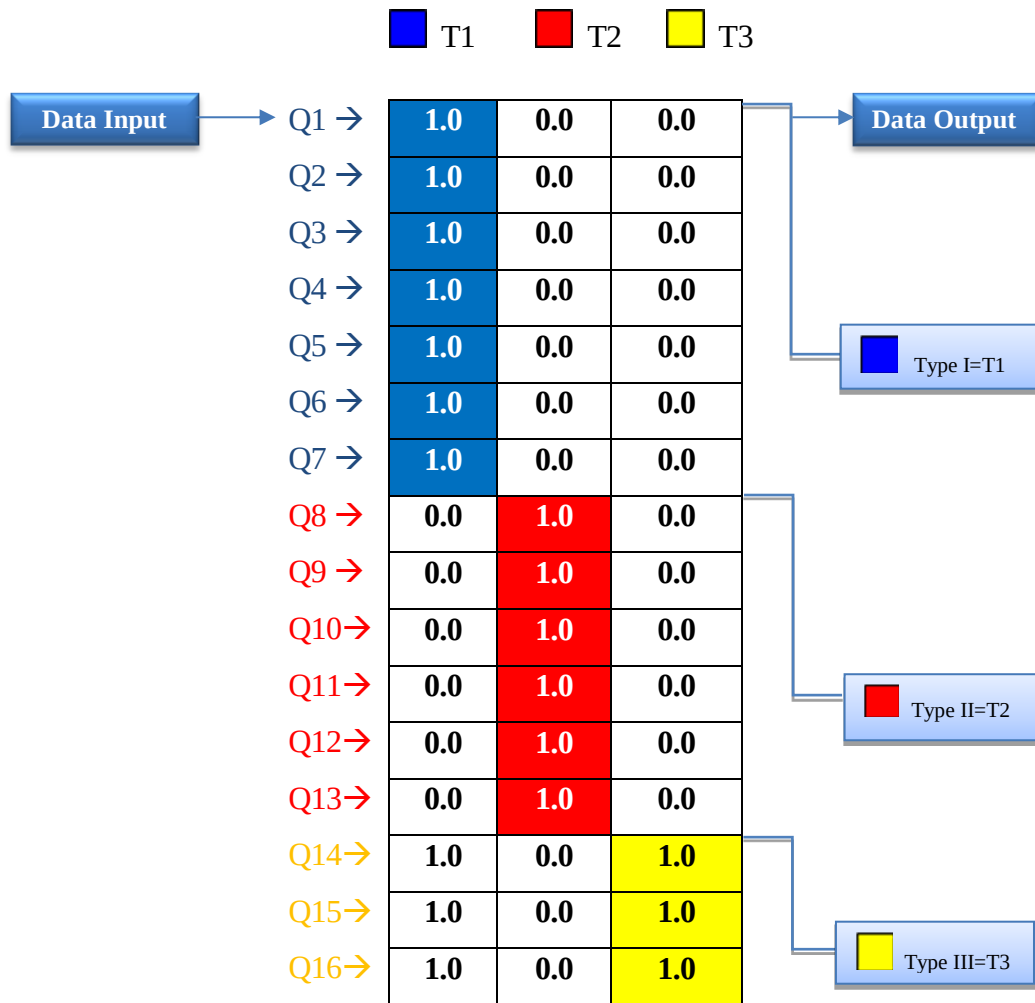
Table 4.1: The input layer represented with the input pattern

Strongly agree	Agree	Average	Disagree	Strongly disagree
100%	75%	50%	25%	0%

Standard Matrix of Thinking and E-learning Style

The results of the above analysis provide the most relevant thinking style questionnaire features. Table 4.2 presents the matrix model that consists of 16 inputs and 3 outputs types of thinking style features. This matrix model is based on the characteristics thinking styles which demonstrates the elements of the three types of thinking style and e-learning style matrix as shown in Table 4.2.

Table 4.2: Thinking style and e-learning style matrix



Data Set Using Neural Network

This section presents the implementation results of the training component of the (70) samples. The data set was divided into three models. Each data set of each model was trained and tested separately. The MLP was implemented using Weka program. Moreover,

the precision and sensitivity as well as the calculation of the error percent were calculated and presented as follows, and is shown in Figure 4.5.

The results of the three models are as the following:

- **Model One (M1) =20**

The first model (M1) was tested and trained in order to measure the performance of the model. For this purpose three measures were considered, those are: Sensitivity, Specificity, and Accuracy.

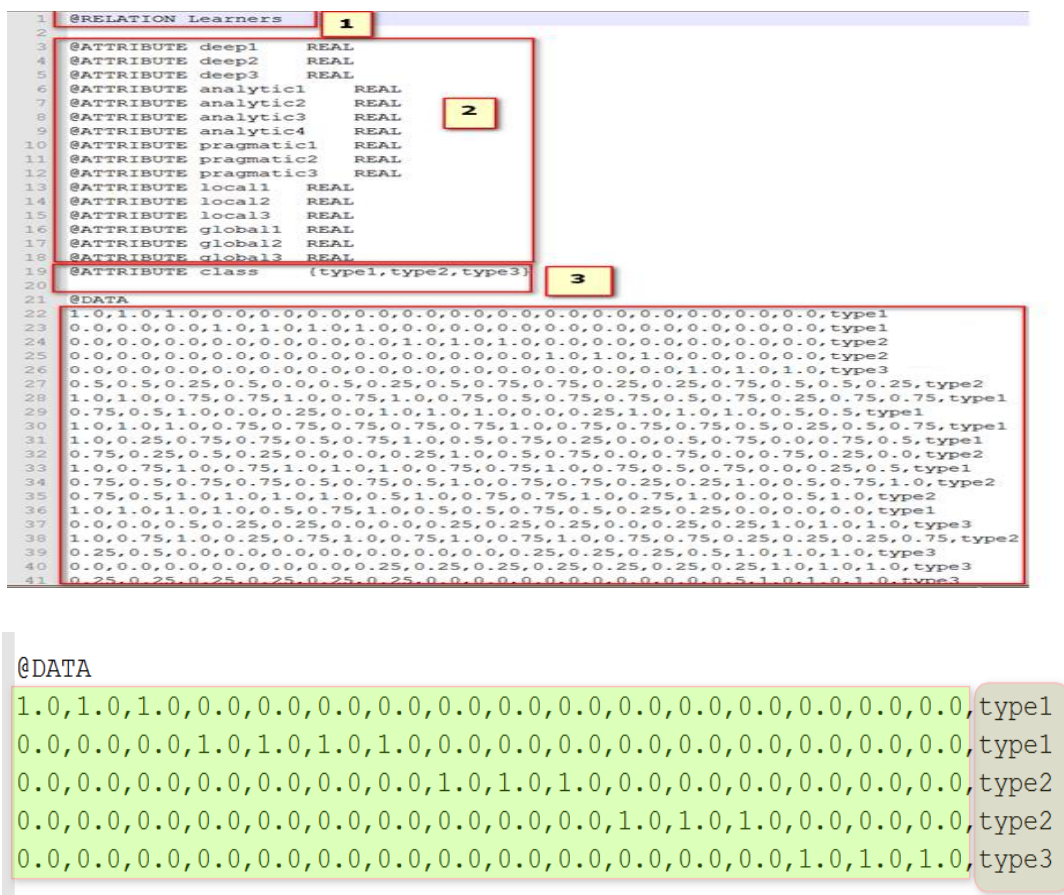


Figure 4.5: Data set for the first model

The training for output from the neural network program results for (20) samples showed that (17) samples were correctly classified which represents (85%), while (3) samples were incorrect which is about (15%) as shown in Figures 4.6 and 4.7 for the training testing, respectively.

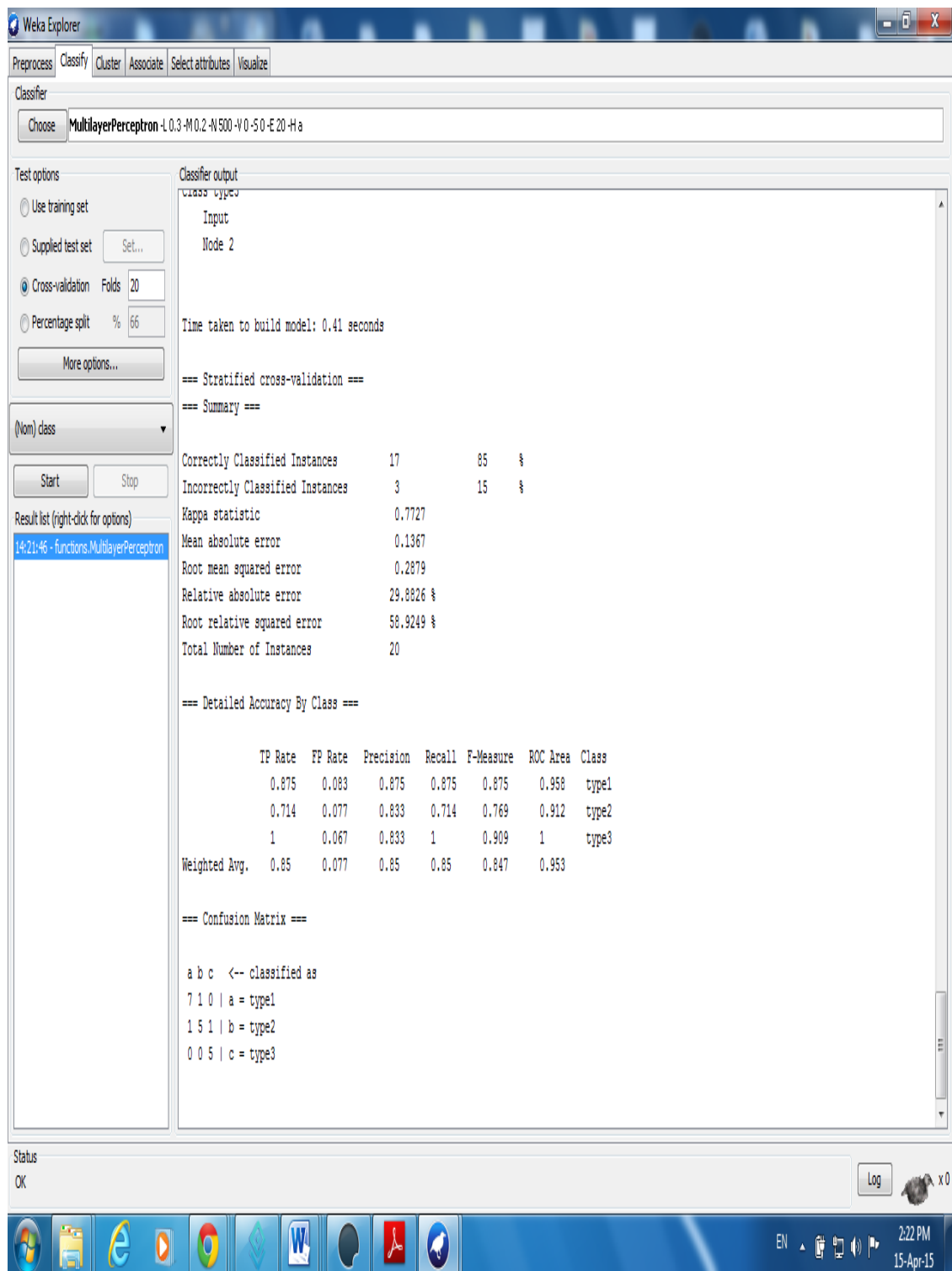


Figure 4.6: The output from the neural network program results for the first model

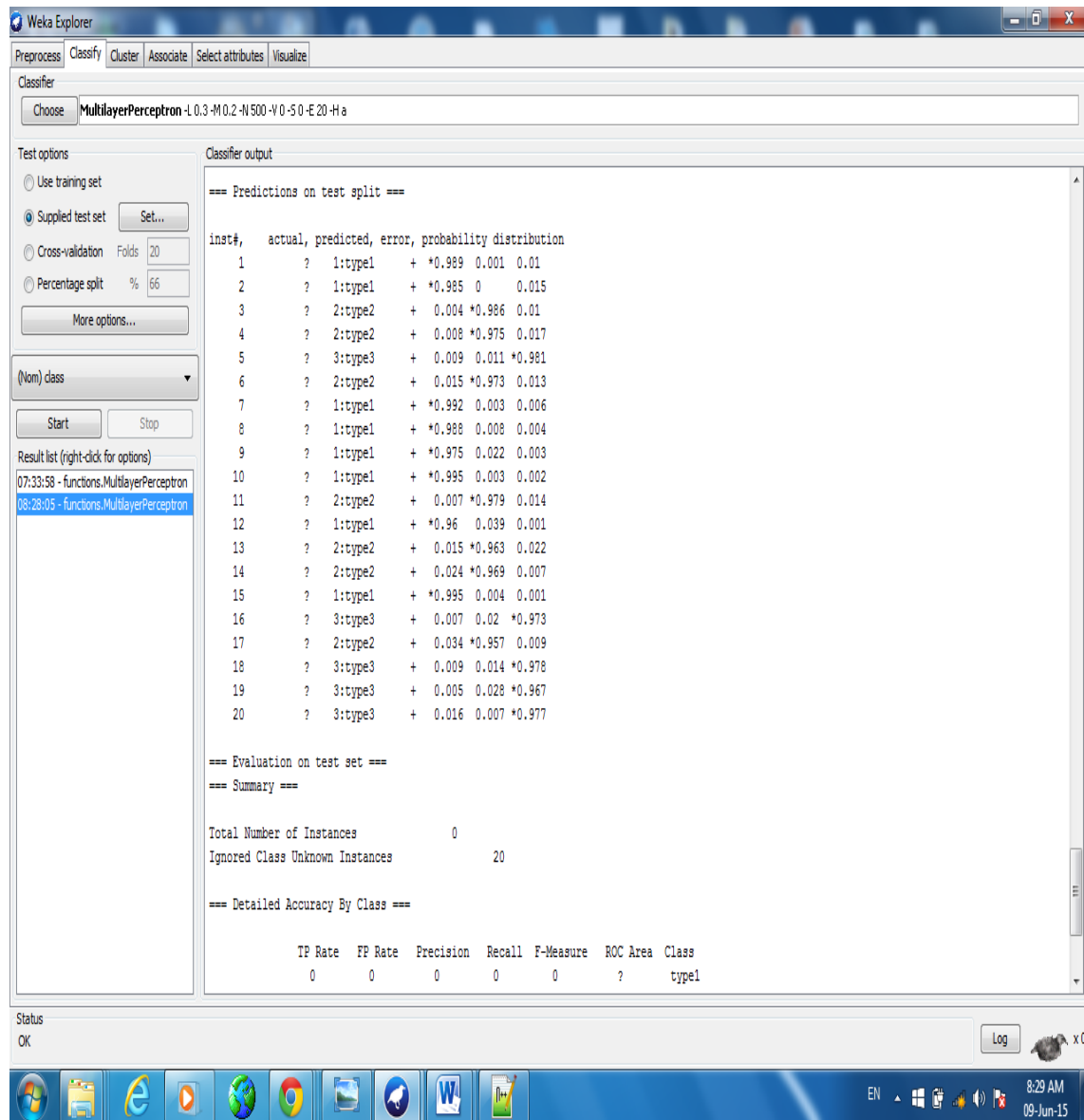


Figure 4.7 testing for model one

Step 4: Calculating the Differences between MLP Algorithm and RBF Network Algorithm

Calculations training for MLP Algorithm and RBF Network Algorithm for Model1 was performed. Two algorithms of MLP algorithm and Radial Basis Function RBF network algorithm were selected and tested based on **ALTENN** model using the formula in Table 4.3. The results of MLP algorithm and RBF network algorithm are presented in the following section.

Table 4.3: Sensitivity, Specificity, Accuracy [23]

Measure	Formula	Meaning
Sensitivity	$TP / (TP + FN)$	The percentage of positive labeled instances that were predicted as positive.
Specificity	$TN / (TN + FP)$	The percentage of negative labeled instances that were predicted as negative.
Accuracy	$(TP + TN) / (TP + TN + FP + FN)$	The percentage of predictions that were correct.

1. MLP Algorithm

The Formulas are:

$$TP + FN = 1.0$$

$$TN + FP = 1.0 [23].$$

The Results

Training for model one (M1) using MLP algorithm is shown in Table 4.4.

Table 4.4: Training for M1 using MLP algorithm

	TP Rate	FP Rate	Precision	Recall (Sensitivity)
Weight Average	0.85	0.077	0.85	0.85

The values of TP and FP from Weka are 0.85 and 0.077 respectively. Then, we calculate:

- $FN = 1.0 - TP = 1.0 - 0.85 = 0.15$.
- $TN = 1.0 - FP = 1.0 - 0.077 = 0.923$.

Then, sensitivity, specificity and accuracy can now be calculated:

- ✓ **Sensitivity** = $(0.85) / (0.85 + 0.15) = 85\%$.
- ✓ **Specificity** = $(0.923) / (0.077 + 0.923) = 92.3\%$.
- ✓ **Accuracy** = $(0.85 + 0.923) / (0.85 + 0.077 + 0.923 + 0.15) = 88\%$.

2. Radial Basis Function (RBF) Network Algorithm

The Results

Training for model one (M1) using RBF network is shown in Table 4.4.

Table 4.5: Testing for M1 using RBF network

	TP Rate	FP Rate	Precision	Recall (sensitivity)
Weighted Average	0.70	0.168	0.741	0.70

Here we have TP = 0.70 and FP = 0.168 values from Weka, so we calculate:

- $FN = 1.0 - TP = 1.0 - 0.70 = 0.30$
- $TN = 1.0 - FP = 1.0 - 0.168 = 0.832$

Then, sensitivity, specificity and accuracy can now be calculated:

- ✓ **Sensitivity** = $(0.7) / (0.7 + 0.30) = 0.70 = 70 \%$
- ✓ **Specificity** = $(0.832) / (0.168 + 0.832) = 0.832 = 83 \%$
- ✓ **Accuracy** = $(0.70 + 0.832) / (0.70 + 0.168 + 0.832 + 0.30) = 0.76 = 76 \%$.

- **Model Two (M2) =25**

The Training for output from the neural network program results showed that from (25) samples (21) samples were correct that is about (84%), and (4) samples were incorrect that is (16%) as shown in Figure 4.9 of the training and test considered.

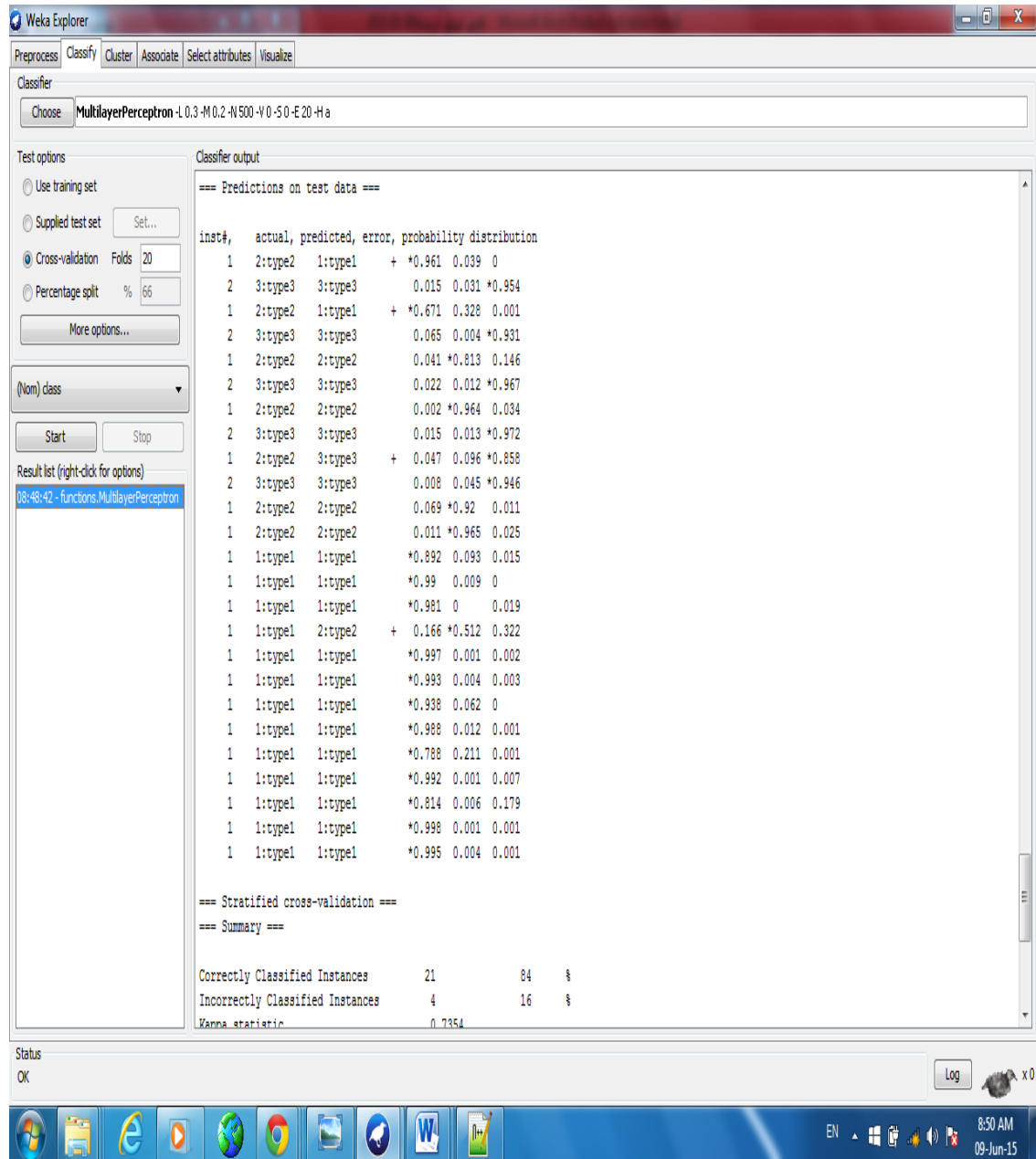


Figure 4.8 the output from the neural network program result for M2

- **Model Three (M3) =25**

The Training for output from the neural network program results that (16) samples out of (25) samples were correct (64%), while (9) samples were incorrect (36%) as shown in Figures 4.10 and 4.11 for the Training and test of M3, respectively.

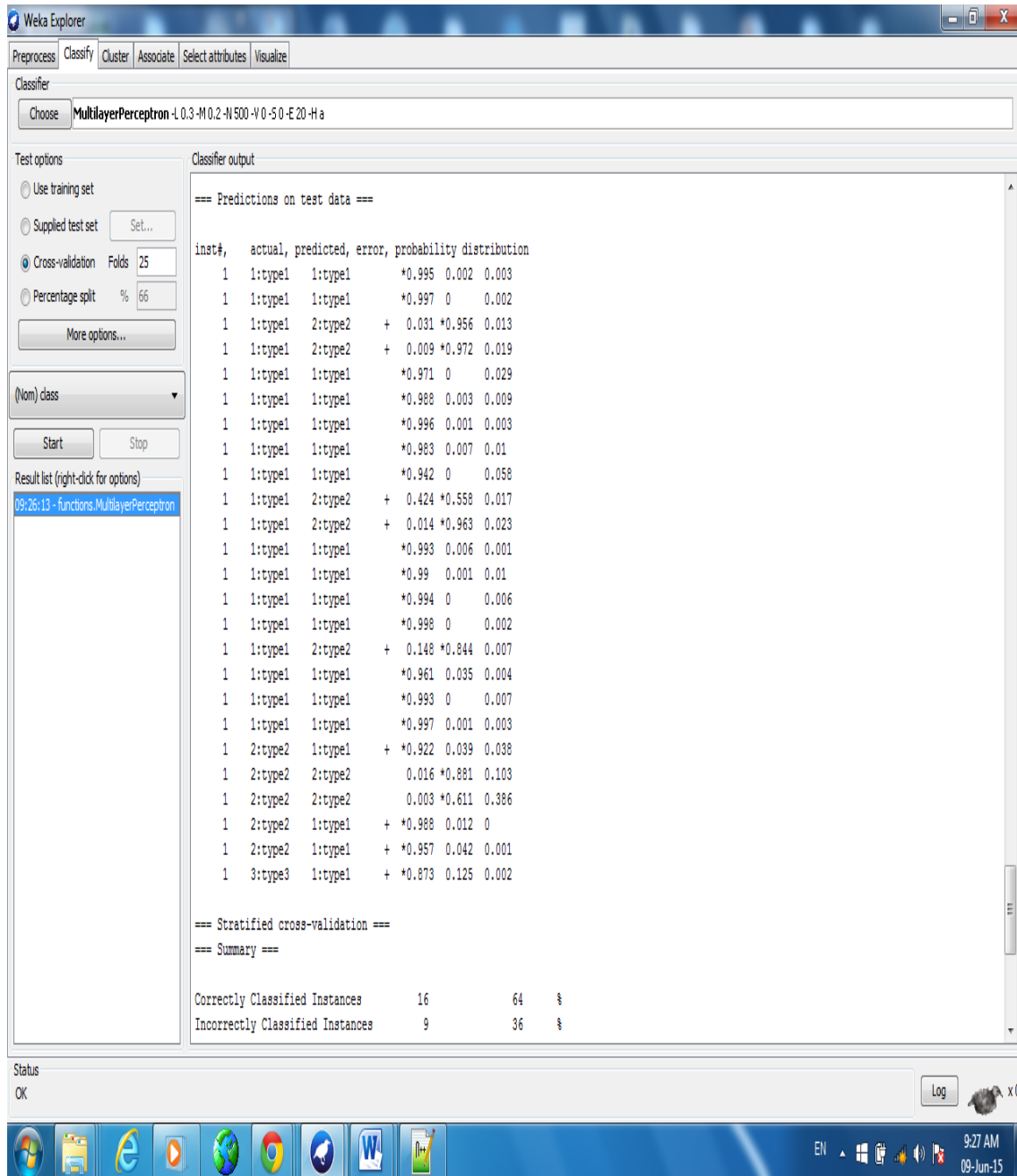


Figure 4.9 the output from the neural network program results for M3

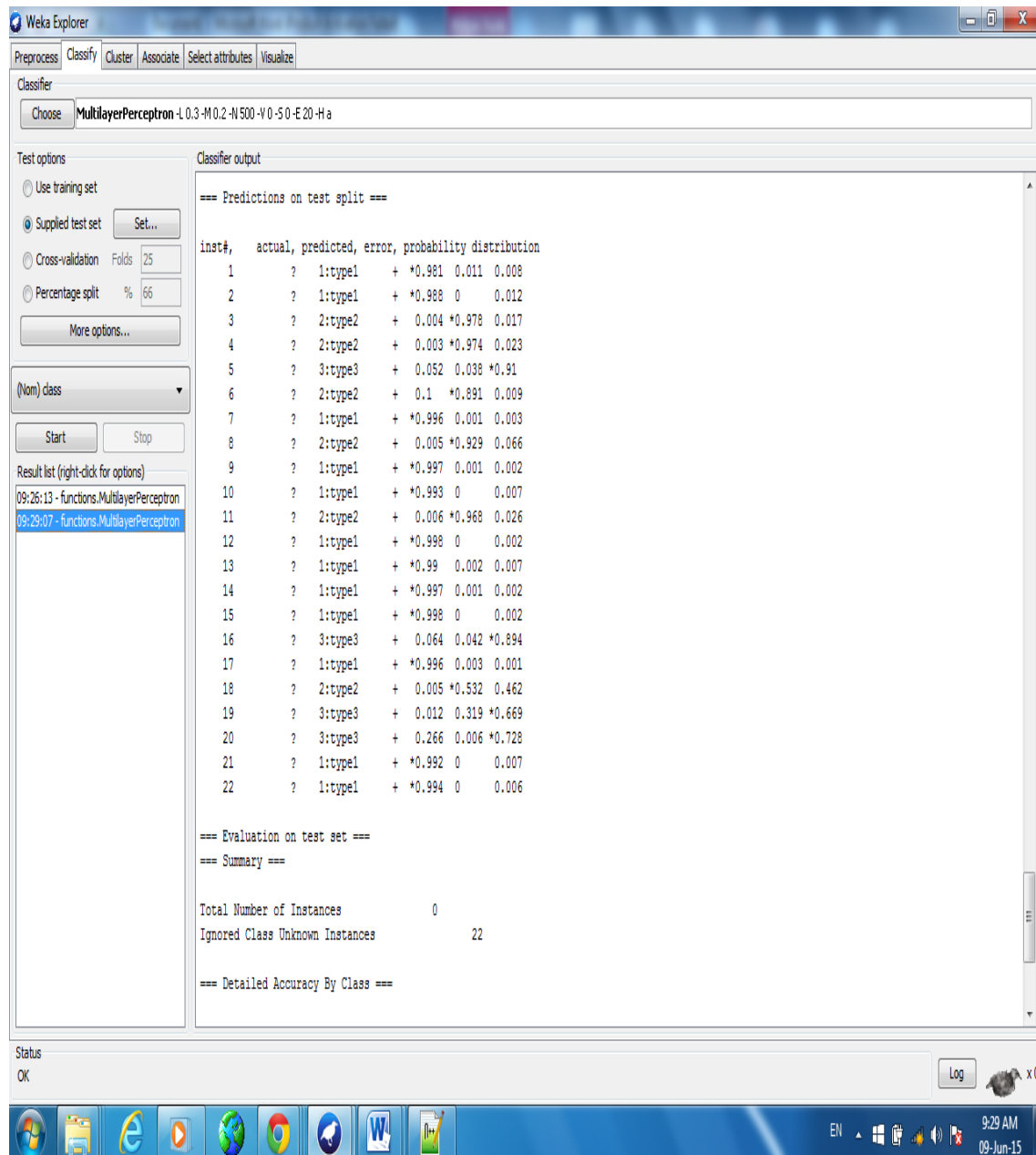


Figure 4.10 the testing for M3

- **Comparison between MLP Algorithm and RBF Network Algorithm**

According to the above accuracy results during the training and testing process of MLP and RBF Network algorithms, the accuracy ratio for MLP algorithm is 88% which is higher than the accuracy ratio of RBF Network which is 76% as shown in Figure 4.8. As a result, the MPL algorithm will be adopted in the process for training and testing in the neural network.

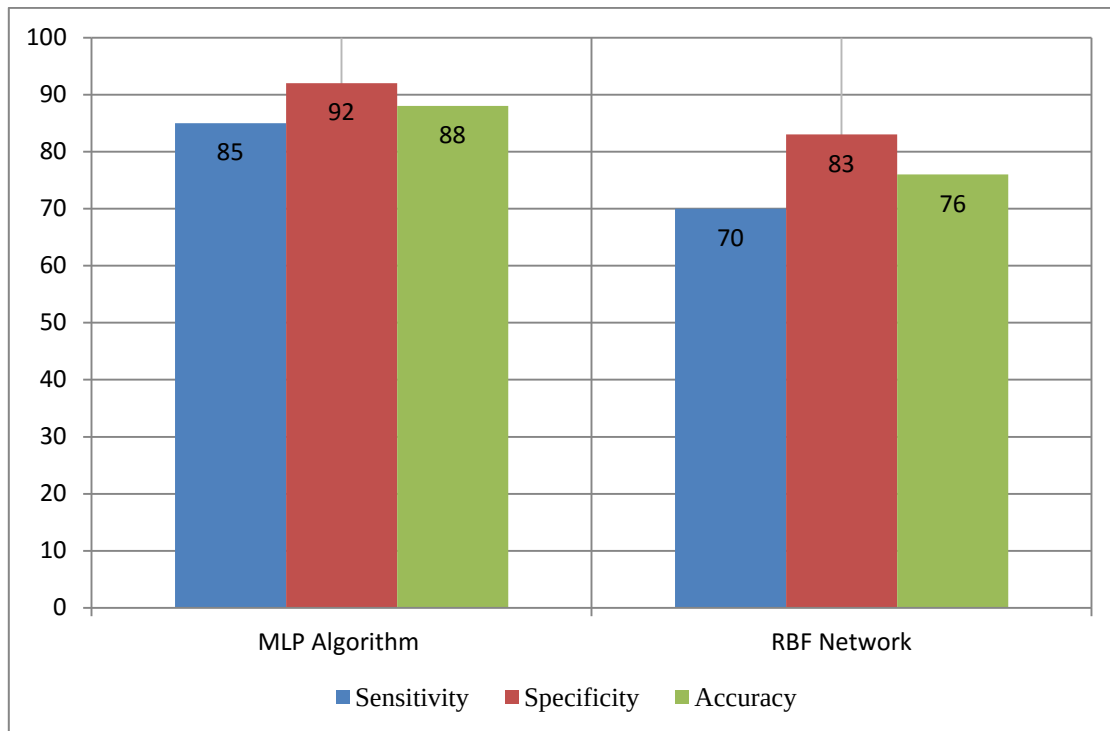


Figure 4.11 Comparisons between MLP Algorithm and RBF Network Algorithm

Step 5: Classification Phase

4.2 Applying ALTENN Model

ALTENN model uses several software with integration of technologies and such techniques for designing ALTENN model.

The following software are used to implement ALTENN model:

1. Weka 3.6.1 application and selection of MLP algorithm for Neural Network building.
2. Notepad++6.7.1 application for data set.
3. Artister 4.1.0.60046 application for interface design.
4. Navicat 8.2 my sql application for data base.
5. Java SE development kit8.
6. Glassfish server.
7. Net Beans IDE8.0.2 application for ALTENN model.

The interface of **ALTENN** model is shown in Figures 4.12 and 4.13.



Figure 4.12 Interface 1 of **ALTENN model**



Figure 4.13 Interface 2 **ALTENN model**

ALTENN model starts by answering the survey in Appendix (A). The learner answer is used as input for the NN system, which will predict the learner's thinking style and identify the most preferred style as shown in Figure 4.14.

4.2.1 Questionnaire page

1 - ☐ 1 Do you have the ability to analyze and study problems ? **deep1**

2 - ☐ 1 Do you have a tendency to link theories to your own experiences in order to solve problems ?

3 - ☐ 1 Do you have the ability to conduct reseaching and use projection to describe your ideas ?

4 - ☐ 1 Do you have a tendency to create an accurate and broad-based view of the problem that you encounter ?

5 - ☐ 1 Do you pay much attention to details when dealing with problems ? **analytic2**

6 - ☐ 1 Do you seek guidance and advice to solve problems ?

7 - ☐ 1 Do you have the ability to analyze the problem and make conclusions ?

8 - ☐ 1 Do you like experimenting and taking gradual steps to solve practical problems ?

9 - ☐ 1 Do you have the ability to come up with new methods to solve a problem ?

10 - ☐ 1 Do you have a tendency to act at leisurely pace when dealing with problems ?

11 - ☐ 1 Do you have a tendency to pay much attention to the little details of the problem ?

12 - ☐ 1 Do you have a tendency to work on the physical part of the problem ?

13 - ☐ 1 Do you like dealing with practical situations and doing experiments to solve problems ?

14 - ☐ 1 Do you have a tendency to ignore details and manage the problem with an abstract attitude ?

15 - ☐ 1 Do you have a tendency to deal with problems generally ?

16 - ☐ 1 Do you have a tendency for recreation and visualizing the problem ?

Figure 4 .14 Identify student thinking style and learning style using the ALTENN model

4.2.2 Results page

Now we create an integer variable to maintain the user's type which will be saved in the database laterals shown in Figure 4.15.

1. If the user's final type is (Type I) then the integer will be 1, if the user's type is equal to 1.
2. If the user's final type is (Type II) then the integer will be 2, and the user's type is equal to 2.
3. If the user's final type is (Type III) then the integer will be 3, and the user's type is equal to 3.
4. Create the needed SQL statement to update the user's data.

```
178 int SQLUserType = 0; 1
179
180 if (FinalResult.equals("type1")) 2
181 {
182     SQLUserType = 1;
183 }
184 else if (FinalResult.equals("type2")) 3
185 {
186     SQLUserType = 2;
187 }
188 else if (FinalResult.equals("type3")) 4
189 {
190     SQLUserType = 3;
191 }
192
193 //declare connection, statement and resultset objects
194 Connection connection = null;
195
196 //SQL statement 5
197 PreparedStatement prepStmt = null;
198 String sqlStmt = "UPDATE users SET UserType=? WHERE ID =?";
```

Figure4.15Learner's type

- **TYPE I** (Analytical style), If the user's type is equal to 1

Your thinking style is type I (Analytic style) and your learning style is visual (v) as shown in Figure 4.16.

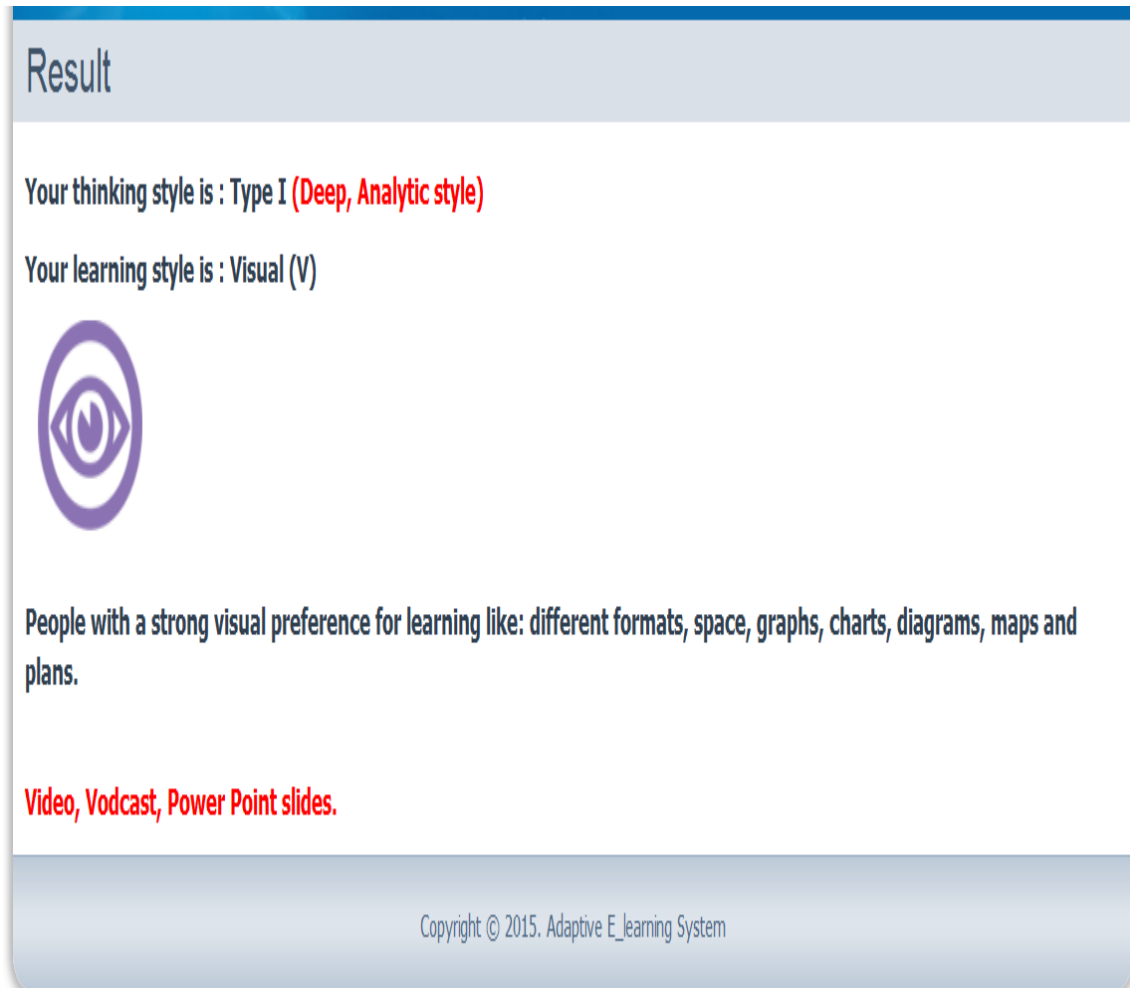


Figure4.16 Thinking and learning style of type I

After the electronic questionnaire of **ALTENN** is completed, and the results are of TYPE I, then the learner thinking style is analytical and learning style is visual. Then, press the icon to show the visual course contents that suits the learning style. These contents are appeared in PowerPoint form or videos.

- **TYPE II** (Pragmatic Style, Local Style), If the user's type is equal to 2

Your thinking style is type II (Pragmatic Style, Local Style) and your learning styles is Aural (A)/ read and write (R), as shown in Figure 4.17.

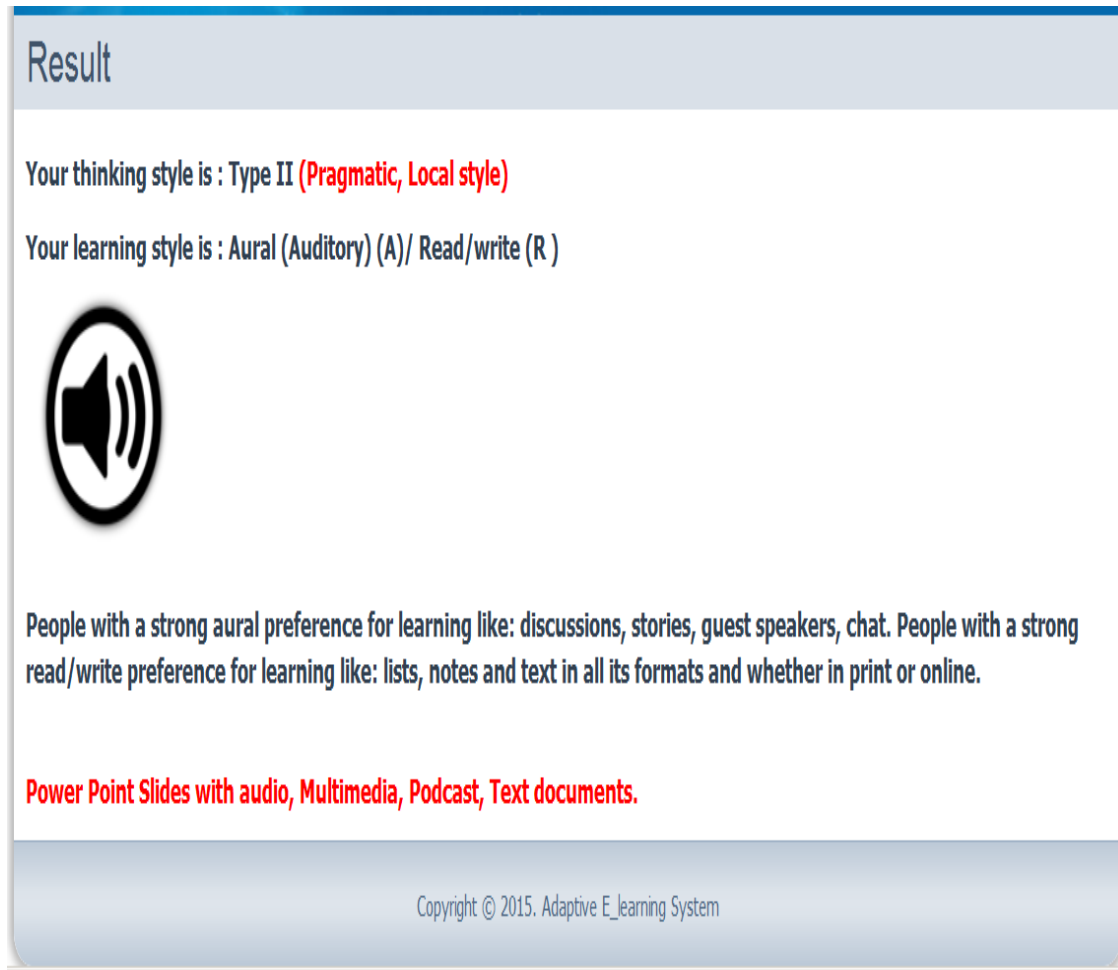


Figure 4.17 Thinking and learning style of type II

After the electronic questionnaire of **ALTENN** is completed and the results **TYPE II**, which means the learner thinking style is pragmatic and learning style is aural. Then, press the icon to show the visual course contents associated with the learning style. These contents are appeared in PowerPoint form with audio or multimedia.

- **TYPE III** (Global Style), if the user's type is equal to 3

Your thinking style is type III (Global Style) and your learning styles is visual (v) and Kinesthetic (K), as shown in Figure 4.18.

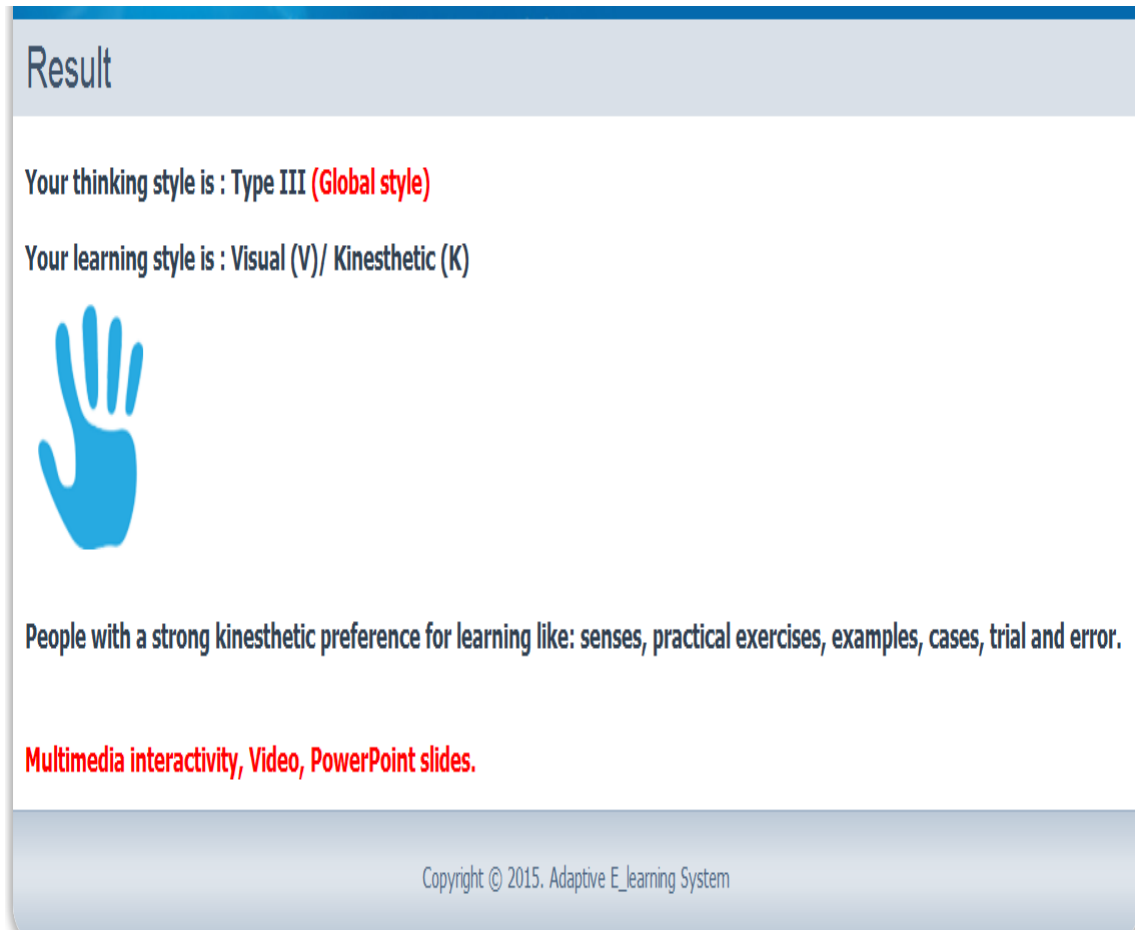


Figure 4.18 Thinking and learning style of type III

After the electronic questionnaire of **ALTENN** is completed and the results **TYPE III**, which means the learner thinking style is global and the learner learning style is kinaesthetic. Then press the icon to show the visual course contents that suits the learning style in the form of multimedia with motion.

4.2.3 Admin Control Panel Page

1. Here the “Add” button was pressed to check the variables received, the course name, location and the targeted users type.
2. Check if the course name and location are not empty variables, then we call the “Add Course” function to insert a new course into the database, otherwise we prepare the appropriate error message to view it to the user as shown in Figure 4.19

Admin control panel

Neural network algorithm : MLP

Save

Save action

Add a new course :

Course name :

Course URL :

Thinking Style :

Add course

Add action

Figure 4.19 Prerequisite main menu and addition course

1. The add course function is used to insert a new course into the database.
2. The variable to hold the error message value.
3. Prepare a connection with the database.
4. Create a new SQL statement to insert the new course.
5. Open the connection.
6. Insert the value of the parameters in the SQL statement.

A sample of the “Add course” function is shown in Figure 4.20

```

242 <!-- Add new course -->
243 <%! void AddCourse(String CourseName, String CourseURL, int TargetType) {
244
245
246 //a flag for success or not
247 String ErrorMessage = "";
248
249
250 //declare connection, statement and resultset objects
251 Connection connection = null;
252
253 //SQL statement
254 PreparedStatement prepStmt = null;
255 String sqlStmt = "INSERT INTO courses (CourseName, CourseURL, TargetType) VALUES (?, ?, ?)";
256
257 //load jdbc driver for mysql database
258 try {
259     Class.forName("com.mysql.jdbc.Driver");
260 } catch (Exception e) {
261
262 }
263
264 //Establish connection using DriverManager
265 try {
266     connection = DriverManager.getConnection("jdbc:mysql://localhost/elearning", "root", "toor");
267 } catch (SQLException e) {
268
269 }
270
271 //if connection is successfully established, create statement
272 if (connection != null) {
273     try {
274
275         prepStmt = connection.prepareStatement(sqlStmt);
276         prepStmt.setString(1, CourseName);
277         prepStmt.setString(2, CourseURL);
278         prepStmt.setInt(3, TargetType);
279

```

Figure 4.20 shows a sample of the contents of an added course function. The code is written in C# and is enclosed in a comment block. The function is named `AddCourse` and takes three parameters: `String CourseName`, `String CourseURL`, and `int TargetType`. The code is annotated with six numbered callouts:

- 1: The function signature `void AddCourse(String CourseName, String CourseURL, int TargetType) {`.
- 2: A comment `//a flag for success or not` and the declaration `String ErrorMessage = "";`.
- 3: A comment `//declare connection, statement and resultset objects` and the declaration `Connection connection = null;`.
- 4: A comment `//SQL statement` and the declaration `PreparedStatement prepStmt = null;`, followed by the SQL statement `String sqlStmt = "INSERT INTO courses (CourseName, CourseURL, TargetType) VALUES (?, ?, ?)";`.
- 5: A comment `//Establish connection using DriverManager` and the `try` block for establishing the connection using `DriverManager.getConnection`.
- 6: A comment `//if connection is successfully established, create statement` and the `if` block for creating the statement using `connection.prepareStatement`.

Figure 4.20 Sample of contents of an added course

4.3 Summary

In e-learning dealing with the behavior is difficult to be represented in scientific research and the creation of an effective mechanism and measures represented by numbers are also complex and difficult. This is because of that e-learning deals with the moral and behavior aspects and to find an effective and measured mechanism, and to present data and results by figures and percentage, through the collection and analysis of data. This is what has been performed and accomplished in this chapter. Qualitative research models of thinking and learning were converted from qualitative research to concrete research to predict the style of thinking in conjunction with the methods of learning based on neural network results developed as a mechanism for e-learning adaptive in this chapter.

Chapter Five

Evaluation and Results

5.1 Evaluation

This chapter presents the testing steps to verify and validate the research questions starting by determining and identify the features of thinking and learning style for the e-learning system identified and analyzed in chapter three. As a result, a frame work of extracting the most preferred learning style based on the learner thinking style was developed and related testing results are presented in this chapter.

The questionnaire was classified into three forms. First form was for 20 learners, and the second and third forms were for 25 learners each. All of these forms were considered for testing using the neural networks techniques based on MPL algorithms to carry out the required classification. It was observed that a higher accuracy was associated with the first form, thus this form was approved and selected to be used to predict the inputs and their classification as well as to connect it with **ALTENN** model that was designed based on the thinking style for the learner.

Questionnaire was conducted based on face to face for 20 learners (Appendix A) to ensure that the result is accurate. The face to face survey explanations were given to the learners to ensure that they understand the details of the survey and answer the questions properly and satisfy the research frame work. A total of 80 copies printed survey distributed to university students in Libya. Ten learners were excluded from the group of those surveyed due to lack of seriousness in answering the questionnaire and total of 70 responses were chosen for this research.

5.2 Survey Results

The survey results for 70 participants were analyzed based on answering what is your thinking style?

The analysis of survey result showed that most people choose Visual (V) style, Type (I) with 63.63% while for typical analytical style and Aural (Auditory) style with 24.24% of Type (II). For typical analytical style and Kinesthetic (K) that is 17.14% of Type (III). The typical analytical style based on the proposed model identified that the most suitable learning style was visual learning, and the survey results are summarized in Table 5.1.

Table5.1: The survey results for 70 participants

Thinking Style	Learning Style	Face to Face Copy& Hard Copy		Total
		No	%	
Type I	Visual (V)	42	63.63%	42
Type II	Aural (Auditory) (A) and Read/write	16	24.24%	16
Type III	Kinesthetic (K) and Visual (V)	12	17.14%	12
The Total All	70			

5.2.1 Neural Network Results

The neural network results were conducted based on several attempts on training of MLP algorithm and RBF algorithm. Those algorithms were used to improve the outcome result. Comparing the results of these algorithms observed that MLP Algorithm provide better results with accuracy of 88%, while 76% accuracy for RBF algorithm.

The MLP algorithm was validated and selected since it provided better expectation and classification to obtain accurate and sensitive results of M1 which was better than M2 and M3 models, and the results as following:

M1: Training of (20) samples showed that (17) samples were correct (85%) and (3) samples were error (15%).

MPL has selected to test 20 face to face responses to verify the accuracy of the neural network. The results were as follows and as shown in Tables 5.2 and 5.3.

- Type I (Analytical Style) =8.
- Type II (Pragmatic style and Local style) =7.
- Type III (Global style) =5.

Table 5.2: Neural network results for MLP algorithm

No	Thinking style (Actual)	MLP Algorithm (Predicted)
1	Type II	Type II
2	Type II	Type II
3	Type II	Type II
4	Type II	Type II
5	Type II	Type III
6	Type II	Type I
7	Type II	Type II
8	Type I	Type I
9	Type I	Type II
10	Type I	Type I
11	Type I	Type I
12	Type I	Type I
13	Type I	Type I
14	Type I	Type I
15	Type I	Type I
16	Type III	Type III
17	Type III	Type III
18	Type III	Type III
19	Type III	Type III
20	Type III	Type III
Accuracy		85%
Specificity		92%
Sensitivity		85%

Table 5.3: Neural network results for RBF network algorithm

No	Thinking style(Actual)	MLP Algorithm(Predicted)
1	Type II	Type II
2	Type II	Type II
3	Type II	Type I
4	Type II	Type II
5	Type II	Type III
6	Type II	Type I
7	Type II	Type II
8	Type I	Type II
9	Type II	Type II
10	Type I	Type I
11	Type I	Type II
12	Type I	Type I
13	Type I	Type II
14	Type I	Type I
15	Type II	Type II
16	Type III	Type III
17	Type III	Type III
18	Type III	Type III
19	Type III	Type III
20	Type III	Type III
Accuracy		70%
Specificity		83%
Sensitivity		70%

5.2.2 The Result of Three Models for Validating **ALTENN** Model

The total of data set was divided into three models for training M1, M2 and M3 and the NN results as follows and presented in Table 5.4.

M1: Training of (20) samples showed that (17) samples were correct by (85%) and (3) samples were incorrect by (15%).

M2: Training of (25) samples showed that (21) samples were correct by (84%) and (4) samples were incorrect by (16%).

M3: Training of (25) samples showed that (16) samples were correct that is (64%), while (9) samples were incorrect with (36%).

Table 5.4: Result of validation of **ALTENN model**

Models	Training		Predictions on test split	Types
	Correctly classified instances %	Incorrectly classified instances %		
Model one → M1=20	17 → 85%	3 → 15%	20 of 20	T1=8 T2=7 T3=5
Model two → M2=25	21 → 84%	4 → 16%	22 of 25	T1=13 T2=7 T3=5
Model tree → M3=25	16 → 64%	9 → 36%	22 of 25	T1=19 T2=5 T3=1
Max → M1=85%	Total= 54	Total= 16	Total=70	

5.3 ALTENN Evaluation

A group of 10 volunteers from the Department of Engineering and information Technology at Libyan Academy of Graduate Studies in Tripoli and Faculty of Computer Technology in Tripoli participated by answering a questionnaire for testing and evaluating ALTEEN (Appendix B). The questionnaire consists of six questions to attain the following objectives:

1. To evaluate the adaptive e-learning-style model.
2. To validate the NN application in adaptive e-learning system.

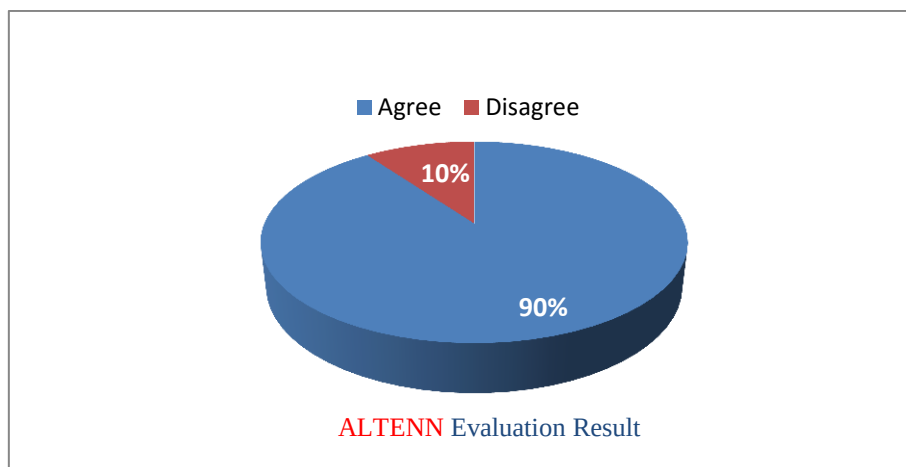
The results of this evaluation were as the following and as shown in Figure 5.1:

- One out of ten was unsatisfied and disagreed on the preliminary results neural network.
- Validating the design and the system structure implementation the result was as follows:
 - All participants stated that structure of the system was comfortable.
 - 100% of the responses approved that ALTENN meets the system requirements.
 - 90% of the responses stated that the system is understandable and easy to learn.
 - Most of them adapted to their preference effectively and strongly agreed that the ALTENN model was successfully met the research objective.

The responses of 10 learners collected for ALTENN evaluation are presented in Table 5.5.

Table 5.5. Evaluation and validation of **ALTENN model.**

Questions	Answers		
Do you think that the suggested thinking approach suit your preferred learning style?	Yes 90%	No 10%	
Do you think that the electronic questionnaire prepared to predict the pattern of thinking and through the provision of learning style is appropriate to you depending on your thinking and individual tastes and effective way?	More general 10%	Appropriate 20%	More detailed 70%
Are the results of the questionnaire regarding the ALTENN model already thinking pattern compatible with you?	Yes 100%	No 0%	
Is learning style of the ALTENN model compatible with the individual preferred pattern?	More general 10%	Appropriate 10%	More detailed 80%
What are your thinking and learning styles you run and whether the ALTENN model is compatible to you?	Yes 100%	No 0%	
What do you think about the ALTENN model in terms of design, operation, and do you have any suggestions or comments about it?	More general 0%	Appropriate 10%	More detailed 90%
What are the good features of this prototype?	More general 0%	Appropriate 80%	More detailed 20%

**Figure 5.1 **ALTENN** evaluation result**

Chapter Six

Conclusion and future work

6.1 Conclusion

In this research, the author has developed a new theoretical model called the Adaptive Learning and Thinking Style for E-learning System using Neural Network **ALTENN** model.

Determining intangible human behavior such as preference or motional aspect is very difficult due to many factors featured in the person's personality, taste, gender, age, and mood. Therefore, determining individuals learning style especially for e-learning and finding the appropriate learning approach that a student prefers in his/her study is a very critical issue. Dealing with different students with different styles of thinking and learning is still the critical issue for most researches. This research presented **ALTENN** model to accommodate learner in convenient learning environment to improve adaptive e-learning system.

Neural network technology has been used to predict the learner learning style based on his/her thinking style and the structure of the system has been developed.

This research objectives are:-

- To provide the required knowledge for teaching by analysis of learner thinking styles and profile.
- To improve adaptive e-learning system by using neural networks.

6.1.1 How do you answer the research question?

You must include the answer her by saying how, and what techniques do you used.

The research questions have been answered as:

Q1- Does analyzing the learner profile based on thinking style and learning style help to improve e-learning environment?

The results of this research emphasize the importance of analysis of thinking styles in order to attain and identify the learning style for each learner. These results were based on the questionnaire and the proposed **ALTENN** model. This model showed its significance and importance in practice as well as to improve the adaptive e-learning systems.

Q2- Does the use of neural networks technique improve adaptive e-learning system based on learning and thinking style analysis?

The neural networks contributed clearly and significantly to analyze and obtain the practical results for the thinking styles. The appropriate learning style associated with the thinking style for each learner was achieved using the **ALTENN** model.

6.2 Contributions

This section presents the research contributions for **ALTENN** model. The main aim for this research is to improve e-learning environment by developing an adaptive e-learning system based on learner preferred thinking and learning style. As a result the following are the main research contributions:

1. The use of neural networks technique improves adaptive e-learning system based on learning and thinking style analysis.
2. **ALTENN** improves adapting the learner into preferred environment based on their thinking style.
3. The analysis of learner thinking style proven that can help to identify the learning style for individual differences.

6.3 The Advantages of **ALTENN** System

An attempt to provide a better environment for e-learning is one of the main advantages of **ALTENN** model:

- **ALTENN** model consists of 16 multiple choices only to determine the pattern of thinking of the learner whereas Kolb made up of at least 40 questions, which are long and the learner may not answer the question accurately.
- In the area of teaching intelligent system the **ALTENN** can help student.
- Learner can learn new information with high efficiency and a shorter time.
- This model can be applied easily with high accuracy in smart technology.
- By knowing the pattern of your thinking you can do activities that fit your preferred learning style.

6.4 Future Work

- Merging multimedia systems with **ALTENN** model will improve the learning environment.
- Improve learning management system (LMS) using **ALTENN** to be more flexible, efficient and effective.
- **ALTENN** model can be used in decision support systems and recruitment of future research for decision support.

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Appendix-A



Questionnaire on **ALTENN** model

Name:

Gender: ☐ Male ☐ Female

Age :

1. Introduction

This research attempts to improve e-learning system through developing an e-learning system to deal with different learners using NN technology. This questionnaire is needed to complete masters' study.

Your cooperation is highly appreciated.

Q1. To extract the thinking style, please choose the more convenient answer. Choose between (5-1) in descending rank for the correct answer?

Strongly agree	Agree	Average	Disagree	Strongly disagree
%100	%75	%50	%25	%0
(5)	(4)	(3)	(2)	(1)

Appendix A

No	Questionnaire	5 Strongly agree	4 Agree	3 Average	2 Disagree	1 Strongly disagree
1	Do you have the ability to analyze and study problems?					
2	Do you have a tendency to link theories to your own experiences in order to solve problems?					
3	Do you have the ability to conduct research and use projection to describe your ideas?					
4	Do you have a tendency to create an accurate and broad-based view of the problem that you encounter?					
5	Do you pay much attention to details when dealing with problems?					
6	Do you seek guidance and advice to solve problems?					
7	Do you have the ability to analyze the problem and make conclusions?					
8	Do you prefer experimenting and taking gradual steps to solve practical problems?					
9	Do you have the ability to come up with new methods to solve a problem?					
10	Do you have a tendency to act at leisurely pace when dealing with problems?					
11	Do you have a tendency to pay much attention to the little details of the problem?					
12	Do you have a tendency to work on the physical part of the problem?					
13	Do you like dealing with practical situations and doing experiments to solve problems?					
14	Do you have a tendency to ignore details and manage the problem with an abstract attitude?					
15	Do you have a tendency to deal with problems generally?					
16	Do you have a tendency for recreation and visualizing the problem?					

Q2. What is the style of your thinking? Put (✓) based on the selection closest to your thinking pattern before thinking patterns in the following table:

Thinking Styles	Characteristics	The result
Analytical Style	This method is characterized by the owners of planning and rationality and theorizing, accuracy and conclusion, perseverance and gathering information with a holistic view of the composition, and the face of the problems carefully and methods of systematic attention to detail and his ability to predict, cares about research and audit, advice and guidance. And characterized by the ability to interpretation, analysis and summary and link their theoretical ideas experiences of everyday life, and they have serious concerns about the study.	
Pragmatic Style	This method is characterized by the owners who prefer adventure and experiments and the search for a immediate solution and concern on the procedural aspects of the work, and on initiation a new solution.	
Local style	The owner of this method is characterized by focusing on the details of the issues, and they tend to logic and the sequence in dealing with issues.	
Global Style	This is characterized by the owners of the public interest in the form of questions and detail, dealing with random. Questions and concerns about the finalization of shapes and images to clarify issues.	
Style of the above-mentioned that closest to your thinking is:		
If you have other qualities that were not mentioned		

Please, add notes if any

.....
.....
.....
.....

Thank you

Appendix-B

**ALTENN Validation Questionnaire**

Name:

.....

Gender: ☐ Male ☐ Female**Age:** ☐**1. Introduction**

Adaptive learning defined as an educational method which uses computers as interactive teaching devices [2]. Computers adapt the presentation of educational material according to student's learning needs. In a learning environment, each individual student will have different requirements and characteristics. An important role of the educator is to recognize that their pedagogy and educational material must meet individual learner's characteristics and requirements. This is true for both the traditional classroom approach and for e-learning. There is a need to change the one size system that fits all to offer personalized learning experience. Although there are many learning style models, theories, and methodology that have been used widely in education, none of them have adequately covered all learning aspects such as personality, scale differences, and preferences. Many researchers have derived and used some elements from these models in an e-learning system but they were insufficient to overcome all e-learning aspects such as learning preferences. The reason for this is that e-learning is unable to deal with individual learning and thinking styles.

2. Objectives

The design model **ALTENN** is the name of the system that has been extracted from the research titled **Addaptive Learning Thinking and Style to Improve E-Learning System Using Neural Network.**

Neural network technology has been used to predict the learner learning style based on his/her thinking style and the structure of the system has been developed.

This research objectives are:-

- To provide the required knowledge for instructors by analysis learner thinking styles and profile.
- To improve adaptive e-learning system by using neural networks

3. Validation Questionnaire

For all statements below, please tick the most appropriate options from your prospective.

3.1 ALTENN model attempts to identify your preferred learning approach based on your thinking style type using NN.

Please write the initial suggested thinking approach _____

Do you think the suggested thinking approach is appropriate to your preferred learning style?

☐ Yes ☐ No

If you have any comment, please specify. If No, what is a better way of representing this feature?

3.2 Do you think that the electronic questionnaire prepared to predict the style of thinking by providing the learning style is appropriate to you depending on your thinking and individual tendencies and is an effective way?

☐ = Strongly disagree.

☐ = Moderately disagree.

☐ = Undecided.

☐ = Moderately agree.

☐ = Strongly agree.

If you have any comment, please specify. If No, what is a better way of representing this feature?

3.3 Are the results of the questionnaire regarding the **ALTENN** model associated with the thinking pattern is compatible with you?

☐ = Strongly disagree.

☐ = Moderately disagree.

☐ = Undecided.

☐ = Moderately agree.

☐ = Strongly agree.

If you have any comment, please specify. If No, what is a better way of representing this feature?

3.4 Is the learning style **ALTENN** model is compatible with your personal learning tendency?

☐ = Strongly disagree.

☐ = Moderately disagree.

☐ = Undecided.

☐ = Moderately agree.

☐ = Strongly agree.

If you have any comment, please specify. If No, what is a better way of representing this feature?

3.5 What are your thinking style and the learning style after you used ALTENN model, and are the results compatible with you?

☐ = Strongly disagree.

☐ = Moderately disagree.

☐ = Undecided.

☐ = Moderately agree.

☐ = Strongly agree.

If you have any comment, please specify. If No, what is a better way of representing this feature?

3.6 What do you think about the **ALTENN** model in terms of design, operation, and do you have any suggestions or comments about it?

☐ = Strongly disagree.

☐ = Moderately disagree.

☐ = Undecided.

☐ = Moderately agree.

☐ = Strongly agree.

If you have any comment(s), please specify. If No, what is a better way of representing this feature?

Q. What are the good characteristics of this prototype?

Thank you