Features of Emerging Technology Learning Materials Suited for Non-Technical Adults

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Keisuke Seya

Dedication

To my wife Chiake, my children Rino, Kano, and my friendly dog Maru, that endured prolonged periods of my absence and absent-mindedness, and to my parents, Koichi and Kiyoko, who taught me the virtue of perseverance, and the grace of virtue.

Acknowledgements

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Besides my advisor, I would like to thank the rest of my thesis committee: Prof. Toma, Prof. Suzuki, and Dr. Hibiya, for their insightful comments and encouragement, but also for the hard question which incented me to widen my research from various perspectives.

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ABSTRACT

Features of Emerging Technology Learning Materials Suited for Non-Technical Adults

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As the fusion of technologies changes the world, there is a class of business professionals who have never learned to program and will not program by themselves but need to communicate with technical professionals and their customers. These people are conversational programmers. A recent study revealed that existing modern learning materials fail to satisfy conversational programmers due to a mismatch with their expectations. In this study, the author sought a solution to this problem by revealing the features of story-based learning materials suited for non-technical adults in the context of emerging technologies. The comparison method was deployed to extract the unique easy-to-understand features of learning materials suited for business professionals. The story-building steps of learning materials for two different types of learners, one for input-only learners and the other for output-required learners, were extracted and compared. The result of the comparison indicates that the features of story-based learning materials suited for non-technical adults are chronological or logically linear and the embracement of not only successful but also failed stories of their own. A new perspective that helps educators classify a previously unmappable group of learners was found in an effort to make a comparison in this study. The novelties of this study are threefold. First, the revealed features indicate that it is not a small step strategy that helps non-technical adult learners, but it is a big step strategy that traces the outline of the subject. Second, the new perspective has broad applicability and could be widely used in other fields. Third, the application of the findings of this study is practical and convenient when educational practitioners make decisions about the type of materials they provide.

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CHAPTER 1:
INTRODUCTION

1.1 Background

The fourth industrial revolution has begun, and its concept has been widely discussed since the World Economic Forum at Davos in 2016 (“The Fourth Industrial Revolution,” n.d.). According to Klaus Schwab, the founder and executive chairman of the World Economic Forum, the fourth industrial revolution is characterized by a fusion of technologies that is blurring the lines between the physical, digital, and biological spheres (Schwab, 2016). Schwab (2016) stated that it is evolving exponentially rather than linearly and disrupting almost every industry in every country, and the emerging technologies such as IoT, AI, Robotics, Biotech will fundamentally change our way of life.

While the higher degree of coupling among our systems is a natural consequence of our demand for greater performance and robustness from those systems (de Weck et al., 2011), de Weck et al. expressed concerns about the management of highly connected complex systems by humans and pointed out that education is key: “In all these systems, humans play a vital role as designers, operators, users, and decision makers. How will these humans—us, our children, our grandchildren, and the generations to come—be able to design, improve, and manage these complex systems and their increased interactions? Education is certainly key. Of all the systems we’ve mentioned, the education system may be the most important of all. It affects all systems in the most direct way”.

Since the fourth industrial revolution is driven by emerging technologies, demand for technically educated people has increased all over the world (Kimura et al., 2019). Several reports warn that the shortage of advanced IT human resources will increase (“Gartner Survey Finds Talent Shortage Considered A Top Risk Among Executives,” n.d.). As recruiting technically talented people to meet fast-changing business needs is costly, several companies have started technical educational programs for existing employees (Weber, 2019).

Governments have also realized the importance of emerging technologies for the fourth industrial revolution and have developed long-term investment plans to drive the growth of new industries, including in developing countries (Manda and Ben Dhaou, 2019). In order to increase the number of people who can contribute to the fourth industrial revolution, the search is on for new and efficient ways of teaching these emerging technologies to different classes of people (NW et al., 2017).

The fourth industrial revolution involves all classes of people regardless of their scholarly background or business role ("Preparing tomorrow's workforce for the Fourth Industrial Revolution | Deloitte | About," n.d.). Recent studies (Chilana et al., 2015, 2016; Wang et al., 2018) found the demand for learning emerging technologies is increasing for both technical and non-technical people. Chilana et al. (2015) revealed the existence of "Conversational Programmers" which represents a class of people who do not play a technical role in a company yet need to understand technologies to improve their participation in technical conversations (Figure 1.1).

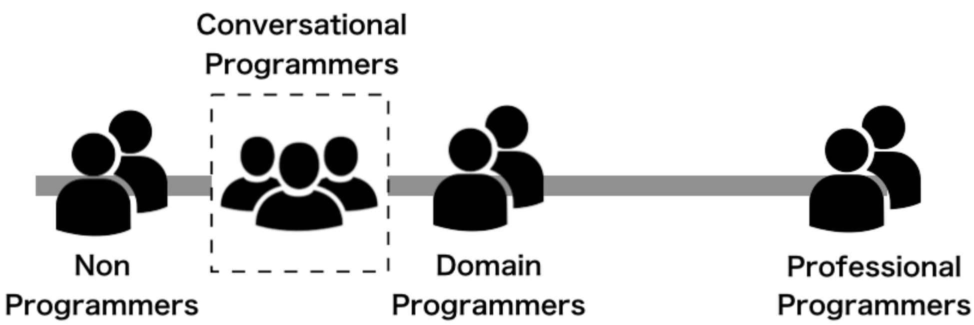

Figure 1.1. Conversational Programmers. Adapted from Chilana et al., 2015

Supporting non-technical adults in learning new technologies is becoming an important issue even in the context of aging societies because older adults comprise a large and fast-growing portion of the population (Guo, 2017).

1.2 Problem Statement

Research about the challenges that conversational programmers face in learning new technologies has found that modern learning resources fail to provide the learning experiences that conversational programmers expect (Wang et al., 2018).

Wang et al. (2018) found that conversational programmers start their journey by searching for learning materials of interest on the internet, but the materials they find are generally designed for technical people (Figure 1.2). Wang et al. (2018) highlighted six reasons why modern resources designed for technical people are not appropriate for non-technical people and attempted to find solutions to these problems.

The problem here is that existing learning materials in technology education do not satisfy business professionals and domain experts in a variety of roles. This dissertation contributes to mitigating this problem.

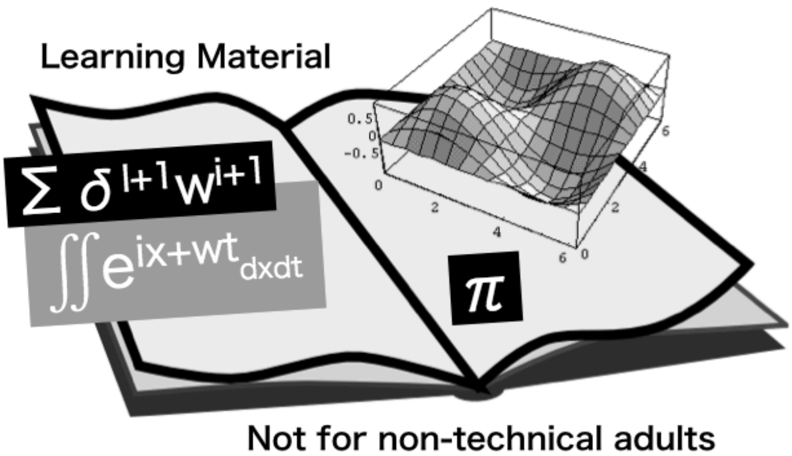

Figure 1.2. Typical Image of Learning Materials not Suited for Non-technical Adults

1.3 Related Works

Attempting to make a use of previous research to solve the educational issues faced by conversational programmers is not possible because of the unique characteristics of conversational programmers. Unlike previously studied groups of learners in computing education, conversational programmers do not program to create artifacts but want to learn programming, and want to use the same tools that professionals use to learn about what the professionals are doing in the field. Figure 1.3 depicts the conversational programmers' unique characteristics unmappable on the axis of conventional groups of learners (Chapter 2 provides a literature review and looks into the nature of the key words depicted in Figure 1.3).

A conventional approach for people to get to know what professionals are doing is to go through the same path the professionals took with the help of learning strategies based on educational theories such as Behaviorism, Cognitivism, and Constructivism. However, this process is time-consuming and therefore does not meet the needs of conversational programmers.

The use of educational tools possibly reduces learning difficulty and shortens learning time, but this does not meet conversational programmers needs either because their purpose is to understand what the professionals are doing. The use of educational tools created for beginners does not satisfy the needs of conversational programmers.

Instructional designs, such as Case-Based Reasoning (CBS) and Goal-Based Scenarios (GBS), which will be reviewed in detail in Chapter 2, help learners acquire authentic skills in a relatively short time. Learners trained through CBS and GBS are expected to be capable of making real artifacts and actions for the case for which they have been trained. Therefore, CBS and GBS are not ideal for conversational programmers.

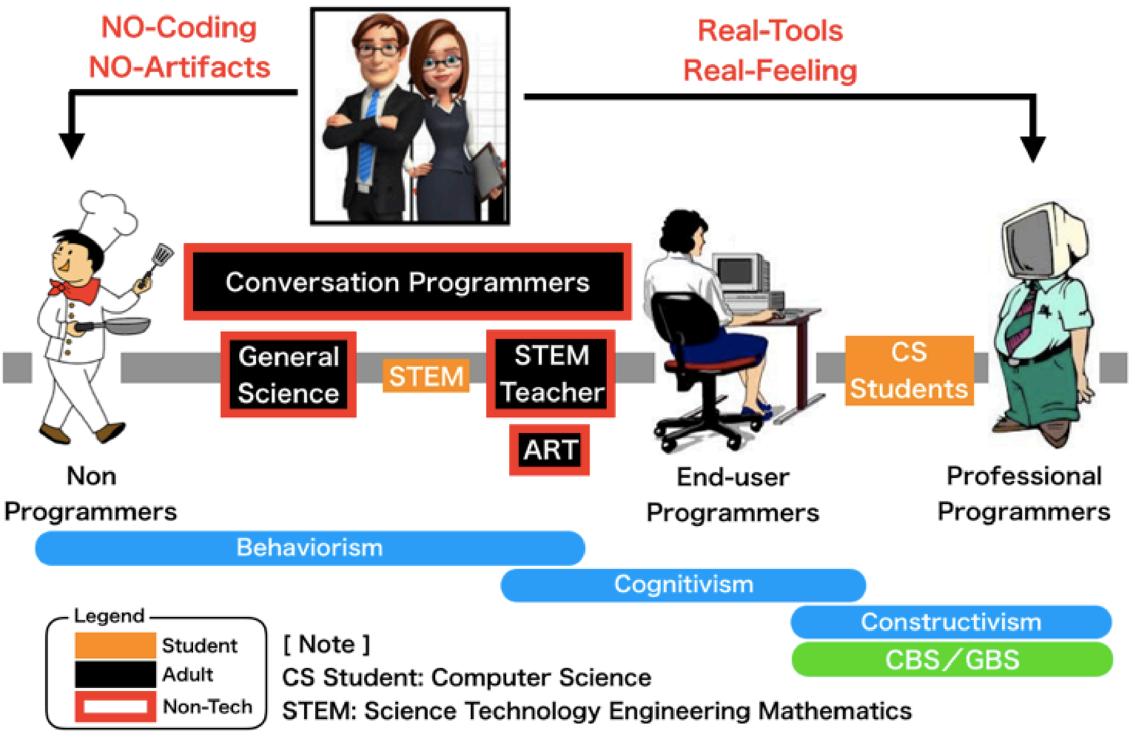

Figure 1.3. Unmappable Characteristics of Conversational Programmers

1.4 Purpose Statement

The purpose of this study is to understand the features of story-based learning materials in technology education suited for business professionals and domain experts in a variety of roles in order to address the need for efficient learning materials for non-technical adult learners when they learn technologies.

This study selected a story-based method to create learning materials even though there are other potential ways. The reason is that we cannot study all the cases, and more importantly, we feel it urgent to identify even one effective method which satisfies business professionals when they learn emerging technologies because we have no evidence that previous and current functional teaching methods work in learning emerging technologies.

1.5 Research Method and Evaluation

We classify learners into two classes; non-technical people and technical people, and design courses suited for each class of people. Business professionals belong to the class of non-technical people.

In order to understand the features of story-based learning materials, we created story-based courses for both non-technical and technical adults and validated their effectiveness. We created three courses as depicted in Figure 1.4. Sync in Figure 1.4 indicates that Course I and Course II are delivered in a way that a lecturer has to be with learners as they are learning. Async indicates that a lecturer does not have to be with learners when the learners are learning (Course III and Course IV).

This process was necessary as the first step for this research because we needed to make sure we had valid courses in terms of effectiveness before we looked into the features of story-based learning materials. We did not implement Course IV in Figure 1.4 in this study, but we tried to make a reasonable assumption for how it should be designed through the study of Course III.

After the validation was completed for each course in Figure 1.4, we extracted the story-building methods for Course I and for Course II and then compared these two methods.

	Non-Tech	Tech
Sync	Course I	Course II
Async	Course IV	Course III

Figure 1.4. Validation of Materials for Each Class of People

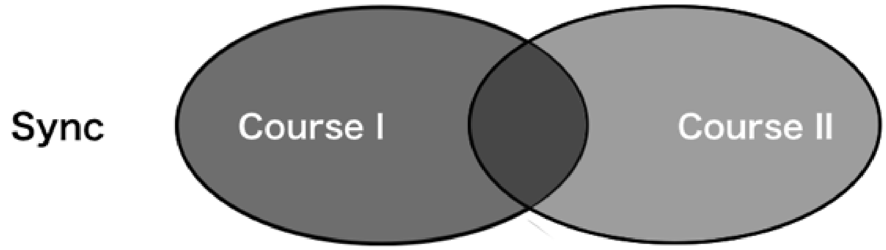

Figure 1.5. Identifying Differences and Similarities Between the Two Story-building Methods

The similarities and differences between the two different story-building methods constitutes new information which is acquired only when the two different sets are compared (Figure 1.5). This new information is what this study primarily pursued because what is unique to Course I is the features of story-based learning materials in technology education suited for business professionals.

We also tried to understand how the course materials are suited for non-technical people online through the study of Course III. The study of Course III identified the five common issues found in two online emerging technology courses for technical people. Once such issues were identified, reasonable assumptions could be made for designing Course IV in the future. We will discuss this later in Chapter 4.

1.6 Contribution

The novelties of this study are threefold. First, the revealed features indicate that story-based learning in this context is not a small step strategy that helps non-technical adult learners, but it is a big step strategy that traces the outline of the subject. Second, the new perspective has broad applicability and could be widely used in other fields deductively. Third, the application of the findings of this study is practical and convenient for when educational practitioners make decisions about the type of materials they provide.

1.7 Structure of the Dissertation

The structure of this dissertation is as depicted in Figure 1.6. Chapter 1 provides an introduction to this dissertation. Chapter 2 introduces the concepts of conversational programmers, education theory, education for adults and instructional design by referring to the literature on these four discourses and summarizing previous research on effective education for technology learners.

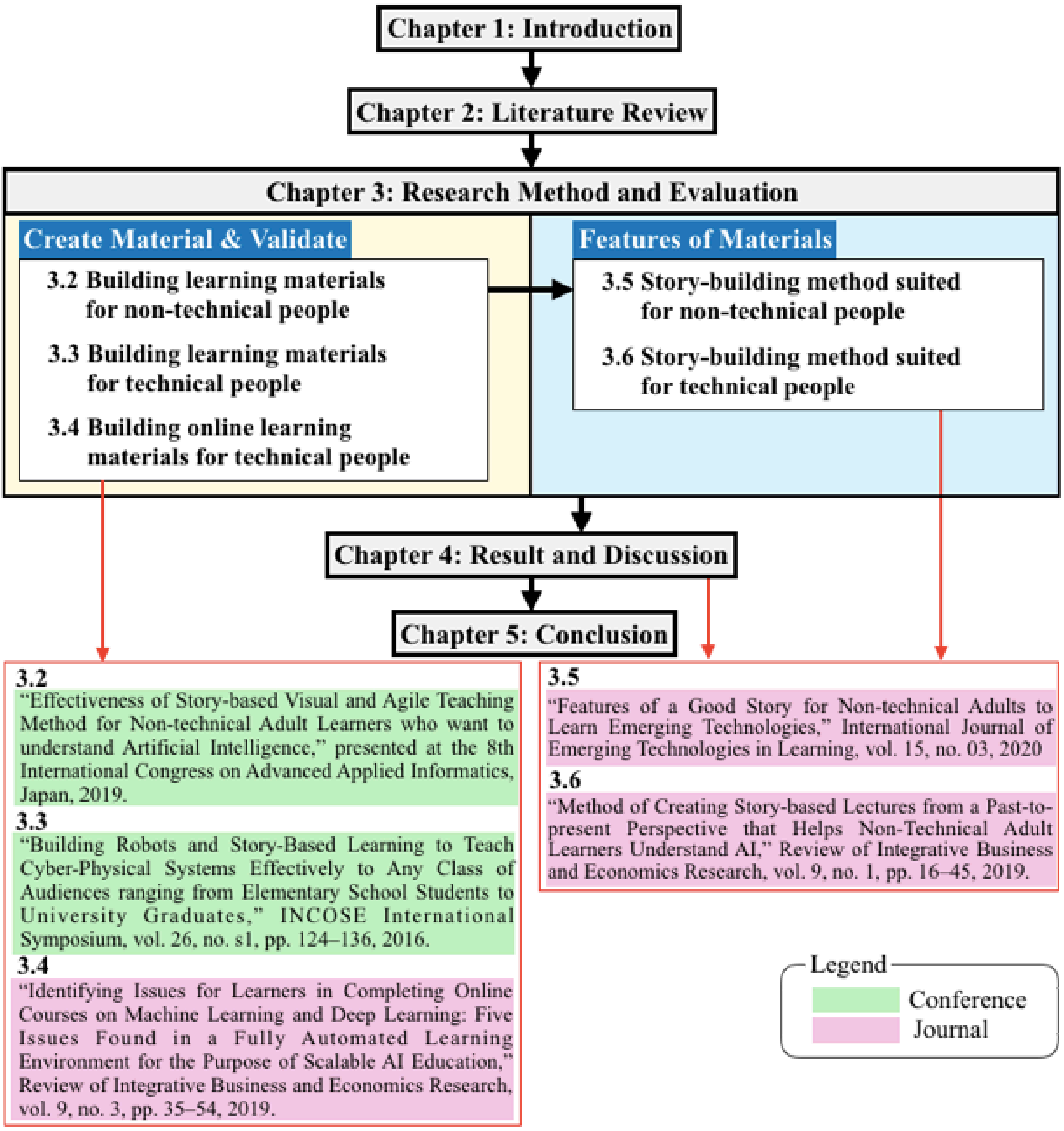

Figure 1.6. Structure of the Dissertation

Chapter 3 presents a description of the research method and the stages of the research process and Chapter 4 presents the findings of this study in detail. Chapter 5 provides an integration of the findings and outlines the contribution of this study. Chapter 5 concludes the study by presenting a summary of the overall research, stating the limitations of the research and providing recommendations for future research.

1.8 Summary

This chapter has provided an overview of this dissertation by highlighting the background, problem statement, related works, purpose statement, research method, and contributions of this study. This chapter also clarified how this dissertation is structured.

CHAPTER 2:
LITERATURE REVIEW

Researchers have long been studying how people learn and found many learning theories which we could utilize when we design learning materials for adults (Merriam, 2017). However, fundamental learning theories were born before the digital revolution and the advent of Internet (Goldie, 2016; Jones, 2015). Today, learners learn differently using the digital tools and the Internet which did not exist or were not widely available when the learning theories were born (Giustini, 2008).

The use of the digital tools and the Internet in education has not only opened the door for both learners and teachers to access the word in completely new ways but also has made memorizing data and rote learning less significant than being able to research, locate and analyze it (Hirtz, 2008).

Following the first section reviews the five major learning theories. The second section reviews three fundamental learning theories for adult learners. The third section covers the instructional design and the fourth section covers conversational programmers.

2.1 Educational Theory

In this section we review the three major educational theories: behaviorisms, constructivism, and cognitivism. They are considered as the foundation of educational theories and still remains valid in the wide range of areas of education but they do not argue intrinsically as instructional design in the 21st century (Masethe et al., 2017).

2.1.1 Behaviorism Learning Theory

In the nineteenth century psychologists began studying how people learn as they were influenced by Charles Darwin and the thoughts of Descartes and Kant (Austin et al., 2001). It was Edward Thorndike (1874 – 1949) who brought a scientific approach to the study of learning and introduced his Stimuli-Response learning theory which largely influenced behaviorism.

Behaviorism focuses on the study of overt behaviors that can be observed and measured (Good and Brophy, 1990). In this theory learning occurs when a new pattern of behavior is observed. It only considers learning to be the production of desired behaviors and totally ignores the possibility of thought processes in the mind (Figure 2.1).

Behaviorism has had substantial influence in education, guiding the development of highly sequenced and structured curricula, programmed instructional approaches, workbooks and other tools. It has proved useful for the development of some types of skills – especially those that can be learned substantially by rote through reinforcement and practice. However, evidence has accrued that tasks requiring more complex thinking and higher mental processes are not generally well-learned through Behaviorism approach and require more attention to how people perceive, process, and make sense of what they are experiencing (Austin et al., 2001).

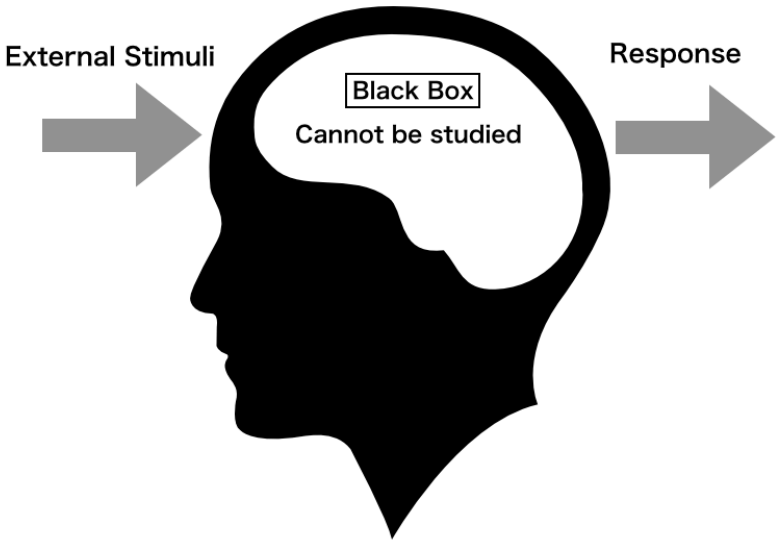

Figure 2.1. Behaviorism Perspective of Learning

This theory is still valid for adult learners in some cases as MacKeracher states that, “Adult educators have the tendency to discount the behavioral approach because the learner may indirectly learn to be other-directed rather than self-directed. However, the behavioral model does provide important insights into the intrinsic and reinforcing value of feedback, particularly when it relates to the learners’ anticipated learning outcomes” (MacKeracher, 2004).

2.1.2 Cognitivism Learning Theory

As early as the 1920’s people began to realize the limitation of behaviorism approach because it could to explain some of high-level learning process. For example, Edward Tolman found that rats used in an experiment seemed to have a mental map of the maze because the rats did not bother to try to a certain path when a certain path was blocked as they knew that it led to the blocked path. Jean Piaget (1896 – 1980) was the first to state that learning is a developmental cognitive process, that students create knowledge rather than receive knowledge from the teacher.

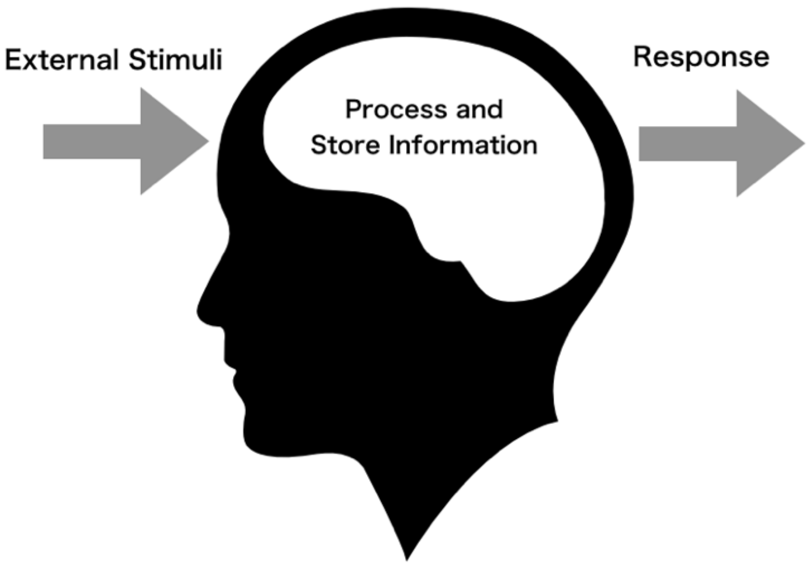

Figure 2.2. Cognitivism Perspective of Learning

Cognitivism focuses on the thought process behind the behavior. While cognitive theorists accept behavioristic concepts, they view learning as involving the acquisition or reorganization of the cognitive structures through which humans process and store information (Good and Brophy, 1990) (Figure 2.2).

When adult learners learn emerging technologies, they have to go through high-level learning process. This theory provides us some clues how to prepare the learning materials suited for non-technical adult learners.

2.1.3 Constructivism Learning Theory

Constructivism is founded on the premise that we all construct our own perspective of the world we live in, through individual experiences and schema (Dennick, 2016). Each of us generates our subjective reality (Figure 2.3) or at least interpret it based upon our perception of experiences, so our knowledge is a function of our previous experiences, mental structures, and beliefs that are used to interpret objects and events (Dennick, 2016).

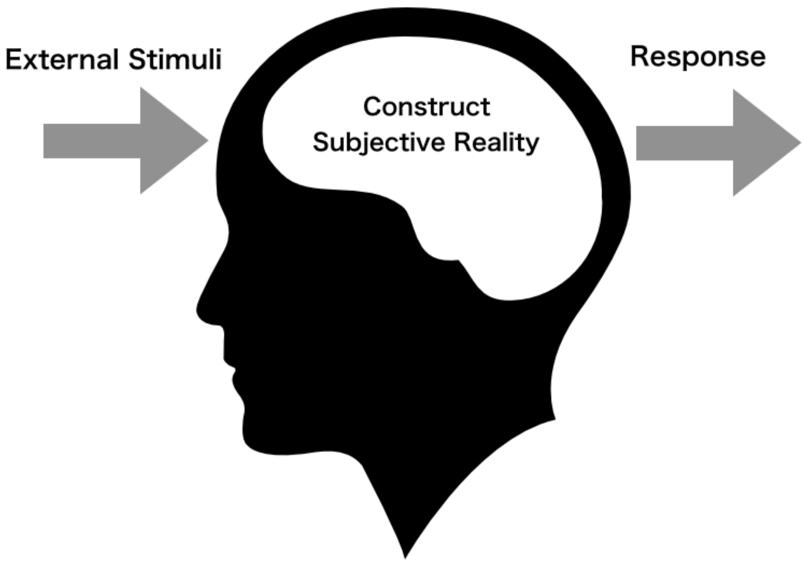

Figure 2.3. Constructivism Perspective of Learning

This theory is rooted in cognitive psychology and states that knowledge do not move into the learner, but the learner has to construct knowledge to accommodate new experiences (Masethe et al., 2017). In this theory learning requires learner's active engagement with the world such as experiments or real-world problem solving, because understanding of the world must come from making meaningful connections between prior knowledge, new knowledge, and the processes involved in learning.

Model building based on active interaction with the world is the result of a cognitive process which involves the experience of the world being assimilated and filtered through prior knowledge. If sense or meaning of new experience can be attached to the previous experiences, then the experience fits with existing cognitive structure (Dennick, 2016).

Since each adult learner brings their unique experience in the learning environment and tries to understand the things through their own filter, we should make sure to take an advantage of the learner's experience when we design story-based learning material for the same reason Ausubel stated "The most important factor influencing learning is what the learner already knows" (Ausubel, 1968).

2.1.4 Connectivism Learning Theory

Connectivism is a learning theory developed by George Siemens and Stephen Downs after the advent of the Internet. This theory is founded on the premise that knowledge exists in the world reasonably than in the head of an individual (Masethe et al., 2017).

Stated simply, connectivism is social learning that is networked (Duke et al., 2013). Stephen Downes described it as: "… the thesis that knowledge is distributed across a network of connections, and therefore that learning consists of the ability to construct and traverse those networks" ("What Connectivism Is," n.d.) (Figure 2.4). Some researchers sees Connectivism as a digital age learning theory .

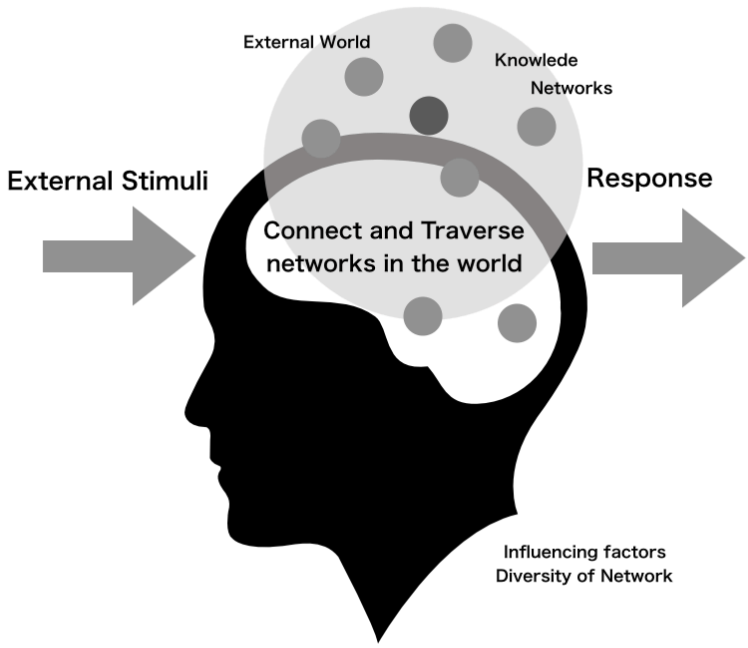

Figure 2.4. Connectivism Perspective of Learning

Connectivism proposes a similar approach to the activity theory of Vygotsky (Vygotsky and Cole, 1978), which regards knowledge to exists within systems. It also holds some similarity with social learning theory which is based on the premises that people learn things through interaction (Mechlova and Malcik, 2012).

While George Siemens proposes connectivism as a learning theory for the digital age as a successor to behaviorism, cognitivism, and constructivism, some researchers argue that this theory is not a learning theory but merely a pedagogical view (Kerr, 2006), or it is simply unnecessary since we already have existing theories that satisfactorily address learning in a technologically connected world (“Connectivism a New Learning Theory | Complexity | Learning,” n.d.). Frances Bell also argues that connectivism will not be built as a theory without significant qualitative studies to inform its development within the context of other theories (Bell, 2011). Kop and Hill conclude that while it does not seem that connectivism is a separate learning theory, it "continues to play an important role in the development and emergence of new pedagogies, where control is shifting from the tutor to an increasingly more autonomous learner." (Mechlova and Malcik, 2012).

2.1.5 Experiential Learning Theory

David Kolb (1984) proposed a learning cycle (Figure 2.5) to describe how we learn from experience and discussed the key components of learning-by-doing. Building the theory upon the work of Dewey, Piaget, and Lewin, Kolb conceptualized that learning from experience requires four different kinds of abilities (Merriam, 2017):

(1) Concrete Experience (CE)
An openness and willingness to involve oneself in new experiences

(2) Reflective Observation (RO)
Observational and reflective skills so new experiences can be views from a variety of perspectives

(3) Abstract Conceptualization (AC)
Analytical abilities so integrative ideas and concept can be created from their observations

(4) Active Experimentation (AE)
Decision-making and problem-solving skills so these new ideas and concepts can be used in actual practice

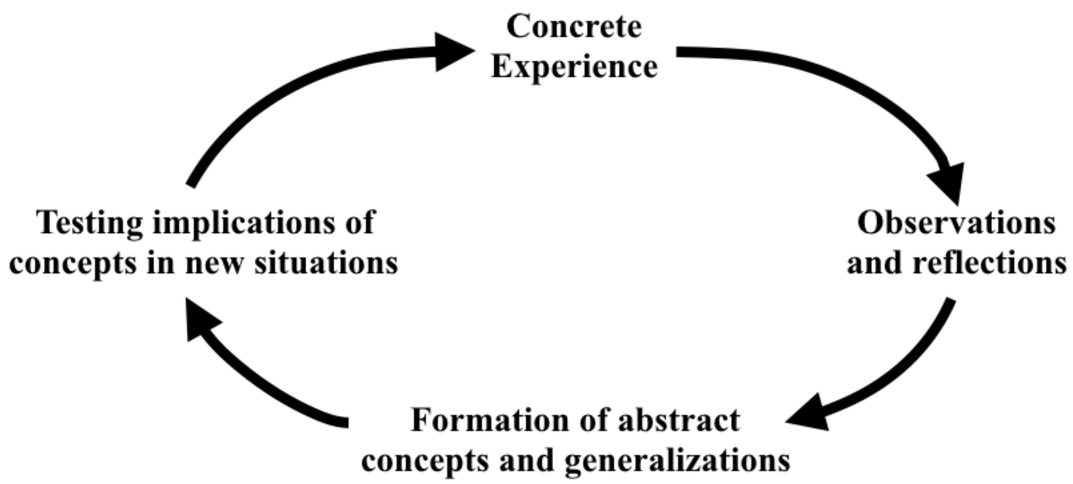

Figure 2.5. Experiential Learning Cycle (Kolb, 1984)

The learning cycle starts from CE and move onto RO, AC, and AE (Figure 2.5). Whatever action is taken in the final it becomes another set of CE, which in turn can begin the next experiential learning cycle (Kolb, 1984).

Baker et. al. (2002) states that Experiential Learning Theory provides a holistic model of the learning process and multi-linear model of adult development. What it means that it is an inclusive model of adult learning that intends to explain the complexities of and differences between adult learners within a single framework (Zhou and Brown, 2015). In the field of adult education practice, descriptions of Experiential Learning have tended to be inherently positive (Jarvis, 2001) and there are many studies have been done in formal adult education programs including online education for adults (Cercone, 2008).

A critique of Experimental Learning is that the learner's context is not taken into consideration (Fenwick, 2003). Jarvis (Jarvis, 2001, 1987) model addresses some of Kolb's (1984) shortcomings as it shows that the person brings his or her biography (i.e. psychological history) into the situation (Jarvis, 2001).

2.2 Educational Theory for Adult Learners

Since learning is so associated with formal classes for school age students, adults often don't recognize or acknowledge that they are continually learning. It wasn't until the early 20th century that learning in adulthood was systematically studied by behavioral and cognitive scientists who were most interested in memory, intelligence, and information processing, and in particular, how age impacted these processes (Merriam, 2017).

In the following sections, the three major fundamental theories of adult learning theories: Andragogy, self-directed learning, and transformative learning.

2.2.1 Andragogy

Andragogy is a European concept and it was Malcom Knowles who made it known to the U.S. in 1970's (Loeng, 2018). He introduced it as a new technology that distinguishes adult learning from children's learning (Merriam, 2017). Knowles proposed the following set of assumptions (Knowles, 1984, 1980):

As individuals mature:

1. Their self-concept moves from one of being a dependent personality towards one of a self-directed human being;
2. They accumulate a growing reservoir of experience that becomes an increasingly rich resource for learning;
3. Their readiness to learn becomes oriented increasingly towards the developmental tasks of their social roles; and
4. Their time perspective changes from one of postponed application of knowledge to immediacy of application, and, accordingly, their orientation towards learning shifts from one of subject-centeredness to one of performance-centeredness (Knowles, 1980).
5. They are mostly driven by internal motivation, rather than external motivations.
6. They need to know the reason for learning something (Knowles, 1984).

Some researchers argue that these assumptions are more about the characteristics of adult learners than about the nature of learning itself (Merriam et al., 1991), and others say that it not clear whether it is a theory or set of assumptions about learning or a model of teaching (Hartree, 1984). Merriam states that "Knowles came to believe there was a continuum ranging from teacher-directed pedagogy on the one end, to student-directed learning (andragogy) on the other end, and both approaches are appropriate with adults and children depending on the situation." (Merriam, 2017)

The set of assumptions provide us a baseline of characteristics of adult learners when we design the learning materials suited for adult learners.

2.2.2 Self-Directed Learning

Self-directed learning (SDL) is one of major adult learning theories which further helped to distinguish adult learners together with andragogy in 1970's. Mezirow states, "no concept is more central to what adult education is all about than self-directed learning" (Mezirow, 1985). While the first assumption of andragogy listed above reflects the self-directed learning nature of adult learners, according Merriam it was Tough's study (Tough, 1971) that contributed to make it a major theory of its own. He found 90% of his participants committed 100 hours of their time in self-planned learning projects which were deeply embedded in their everyday lives.

SDL is all about the learners taking control of their own learning instead of sitting in a room and learning something. The self-directed learners are willing to take an initiative on their learning process. SDL can be found in the everyday lives of adults, including workplace, continuing professional education, health and medical fields, (Merriam, 2017). Also, research suggests that the more successful online learners are more self-directed (Brady, 2015).

Conversational programmers who do not write code by themselves but learn programming in order to improve their communication skill with technical people are the self-directed learners. We need to design the learning materials for self-directed adult learners who should be able to achieve their goal if the materials are properly provided.

2.2.3 Transformative Learning

Transformative learning focuses on the cognitive process of meaning making while andragogy and self-directed learning focus on the characteristics of adult learners to a large extent. This type of learning is considered an adult learning theory because it is dependent on adult life experiences and a more mature level of cognitive functioning that found in childhood (Merriam, 2017).

Transformative learning was first introduced by Jack Mezirow (1978) as a theory of adult learning which helped explain how adults changed their perspective of the world. This theory of transformative learning is considered uniquely adult that is grounded in human communication (Taylor, 2017) where "learning is understood as the process of using a prior interpretation to construe a new or revised interpretation of the meaning of one's experience in order to guide future action" (Mezirow, 1996).

Ten-step transformation process was proposed by Mezirow (2000) still frames much of today's research (Merriam, 2017). This process is often initiated by a disorienting dilemma and adults are challenged to examine their current assumptions and beliefs (Mezirow, 2000). The examination of the current beliefs leads them to explore new ways of dealing with the dilemma which would be recognized and lead them plan to change their belief and attitude (Mezirow, 2000).

2.2.4 Neuroscience and Andragogy

Andragogy as a research topic has had both advocates and detractors (Merriam, 2001). Therefore, several researchers have been making an effort to explain or analyze Androgogy from neuroscience perspective (Hagen and Park, 2016; C. Wilson, 2006).

For example, Neuroandragogy is a field that examines the intersection of Neuroscience and Andragogy ("How the Adult Brain Learns," n.d.). Neuroandragogy is considered to be an effective strategy in adult education because it is based on proven results of research on the cognitive neuroscience and on verified knowledge on psychophysical functioning of an adult ("About neuroandragogy – Neuroandragogy," n.d.).

Hagen and Park (2016) provided an integrative review about why and how anagogical principles work through the lens of cognitive neuroscience. They state that the lens of cognitive neuroscience helps to establish why the much analyzed and often criticized field of Andragogy (Cozolino and Sprokay, 2006; Leuner et al., 2006; Lövdén et al., 2013; Merriam et al., 2006; Taylor and Kroth, 2009). Figure 2.6 helps to establish the working structures of cognitive neuroscience with Andragological assumptions.

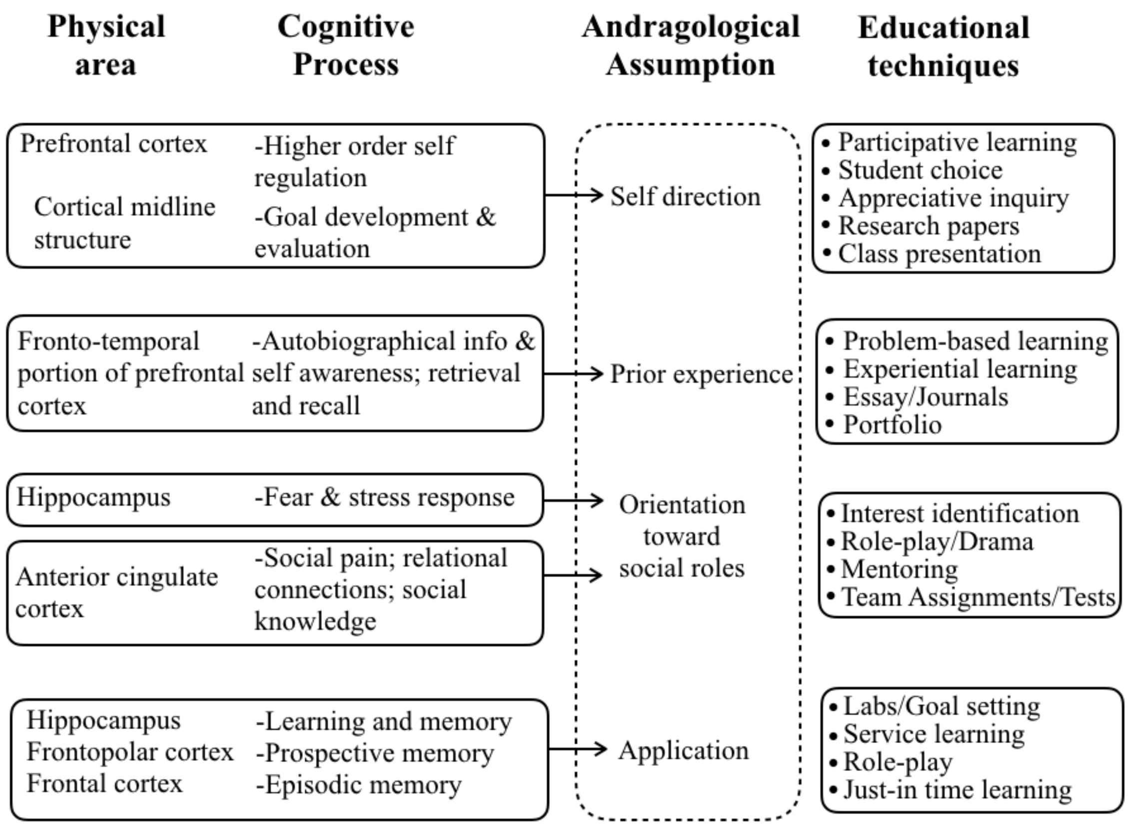

Figure 2.6. A model of adaptive cognitive neuroscience-adult learning structure (Hagen and Park, 2016)

2.3 Instructional Design

Instructional design (ID) refers to a model or research field that compiles methods for enhancing the effectiveness, efficiency, and attractiveness of educational activities, or a process that realizes a learning support environment by applying them (Suzuki, 2006). This definition implies that ID has an eclectic nature of taking whatever helps the educational activities or a learning environment be productive for the learners.

While ID has its roots in behavioral and cognitive psychology (Mayer, 1992), it is also influenced by constructivism (Jonassen, 1991) and still try to adopt itself to a new context as new learning concepts and technologies come along. ID is a dynamic and fluid field and the ongoing shifts and evolution of the field force instructional designers to constantly adapt and evolve with it (Sharif and Cho, 2015).

The origins of ID procedures have been traced back to World War II (Dick, 1987). A large number of psychologists and educators contributed to the development of training materials for military services and also demonstrated significant increase in the percentage of personnel who successfully completed the programs (Gagné, 1985). After World War II, during the late 1940s and throughout the 1950s, psychologists started viewing training as a system, and developed a number of innovative analysis, design, and evaluation procedures (Dick, 1987).

Some researchers looking at ID critically instead of looking at the comprehensive aspects of ID to try to shed light on how learning and instruction might be designed better (Li and Reigeluth, 1995). Streibel states that ID should find ways to design resources rather than plans for teachers and learners if design is regarded as process rather than product. In his words, "instructional theories should be treated as resources, rather than plans", because "all human practice is situated in an ongoing context that requires continual judgement" (Streibel, 1991). This dissertation shares the same spirits we find in his statement for the emphasis on designing resources.

In the following sub-sections, we review one of the fundamental principles and a generic model commonly used in the instructional design as they have been utilized in any class of learners including adult learners.

2.3.1 Nine Events of Instruction

The process involved in act of learning are, to a large extent activated internally but such process may also be influenced by external events which make instruction possible (Gagné et al., 1992). According to Robert Gagné (1992), learning occurs through a series of the following nine events:

1. Gaining attention

   Help learners focus on relevant portions of the learning task
2. Informing learner of the objective

   Tell learners what they are about to learn
3. Stimulating recall of prior learning

   Help learners retrieve prior knowledge helpful in achieving new objectives
4. Presenting the stimulus material

   Expose learners to the information that they will be learning
5. Providing learning guidance

   Provide clues for learners to understand and remember what they are to learn
6. Eliciting the performance

   Give learners an opportunity to demonstrate that they have learned
7. Providing feedback about performance correctness

   Give learners information about the adequacy of their responses in step 6
8. Assessing the performance

   Assess whether the learners have achieved the learning objectives

9. Enhancing retention and transfer

   Allow learners to review and extend new knowledge in order to make it available for subsequent tasks

Gagné sees that instruction consists of a set of events external to the learner designed to support the internal processes of learning (Gagné, 1985). It should be realized that sometimes, one or more events may already be obvious to the learner and therefore, may not be needed. Also, sometimes events are provided by learner themselves, especially when they are experienced self-learner (Gagné et al., 1992).

2.3.2 ADDIE Model

The ADDIE model was initially developed by Florida State University to explain "the processes involved in the formulation of an instructional systems development (ISD) program for military inter-service training that will adequately train individuals to do a particular job and which can also be applied to any inter-service curriculum development activity" (Branson et al., 1975). When ADDIE model first appeared, it was mostly a linear or waterfall model (Branson et al., 1975). However, it has evolved into a more dynamic and interactive model by 1984 which was led by the U.S. Armed Force ("ADDIE Model," n.d("ADDIE Model," n.d.).).

ADDIE model is considered to be a generic ID model due to a common idea in the ID field that ID models usually consist of five phases, namely analysis, design, development, implementation and evaluation (Seels and Glasgow, 1998). ADDIE model provides instructional designers a simple and easy framework for the design of the instruction (Khalil and Elkhider, 2016). Followings are the descriptions of five phases and Figure 2.7 depicts how they relate each other.

1. Analysis**:**

The analysis phase includes the analysis of the learner, context, and instructional materials to define the target learner's characteristics, attitudes, culture and interests, and to decide on overall goals and learning context such as learning environment like on-line or off-line.

2. Design**:**

The design phase consists of the identification of learning objectives mapped with the delivery methods, types of learning activities and different types of media.

3. Development**:**

The development phase includes the creation of instructional contents, a prototype and assessment instruments.

4. Implementation

The implementation phase executes the instructions for learners by delivering the instructional materials.

5. Evaluation

The evaluation phase consists of formative and summative evaluation.

Formative evaluation means the evaluation which occurs during the development phase, while summative evaluation means the evaluation after the process (Branch, 2009).

While ADDIE model is considered to be a generic ID model, there are many other ID models. Gustafson and Branch classified ID models into three categories as classroom, product and system-oriented models (Gustafson and Branch, 2002). Such categorizations may provide intuitive guidance for instructional designers to choose an ID model by considering the purpose, scope and structure (Donmez and Cagiltay, 2016).

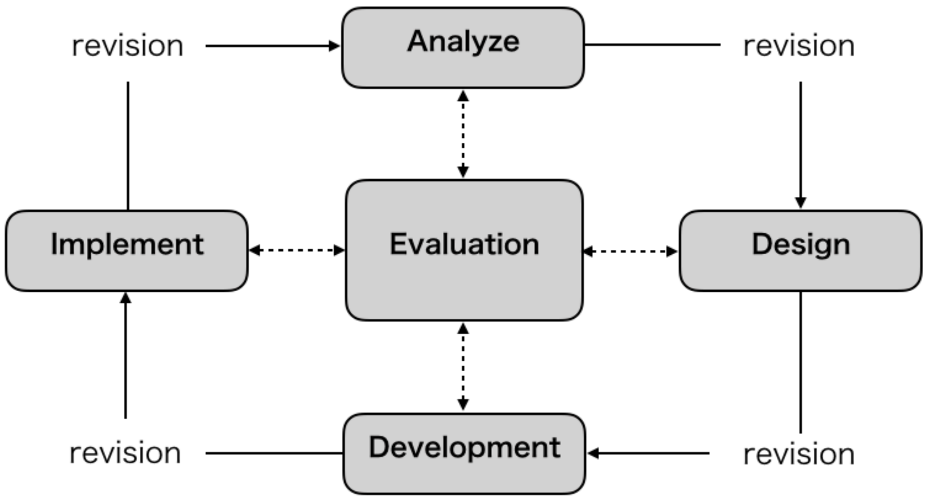

Figure 2.7. ADDIE Model

2.3.3 Case-Based Reasoning

Case-Based Reasoning (CBR) is a type of AI approach to problem solving and learning (Althoff, 2002). Aamodt and Plaza (1994) argue that the problem-solving approach with CBR is different from major AI approaches in many respects as it does not solely depend on a general knowledge of the problem domain and general associations between descriptors and conclusions. Instead, CBR utilizes a specific knowledge of previous experiences (cases) to solve a new problem by finding a similar past case and reusing it in the new problem situation.

The other important difference is that CBR is an incremental, sustained learning process since a new experience is retained each time a problem has been solved by revising the solution based on reusing a previous experience, making it immediately available for future problems (Aamodt and Plaza, 1994). Figure 2.8 illustrates the CBR cycle.

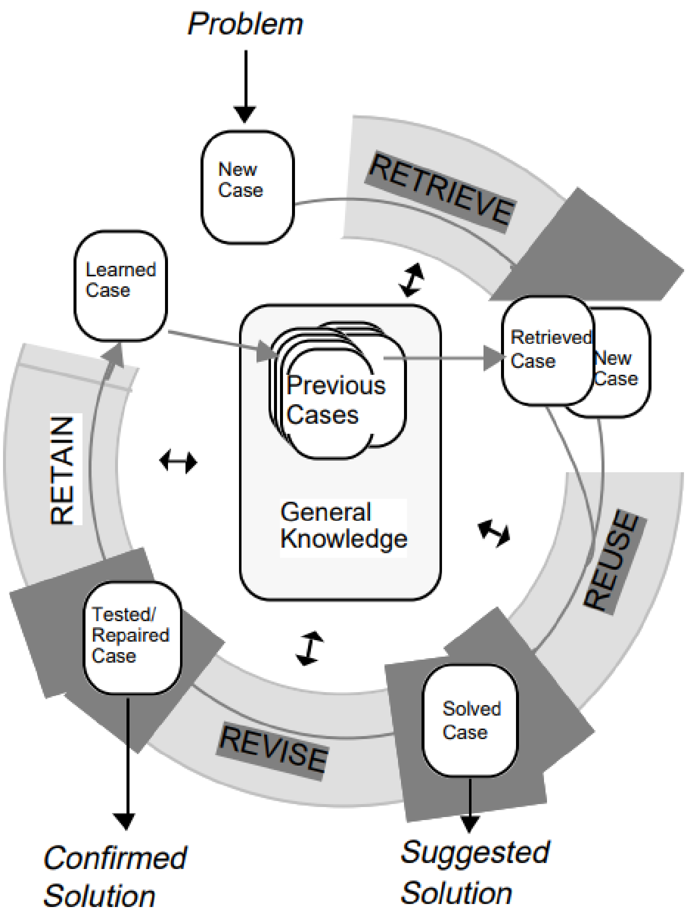

Figure 2.8. CBR Cycle (Aamodt and Plaza, 1994)

Following is a general CBS cycle described as a four process-cycle(Aamodt and Plaza, 1994) :

1. RETRIEVE the most similar previous case or cases to a new case
2. REUSE the knowledge of retrieved case or cases to solve the problem
3. REVISE the suggested solution
4. RETAIN the parts of this experience useful for future problem solving

Shank et al. (1999) says, "CBR is, generally, how people become experts and how experts often reason about problems in their domains of expertise (Riesbeck & Schank, 1989)."

2.3.4 Goal-Based Scenarios

Goal-based scenarios (GBS) is an instructional design theory for creating story-based learning materials (Suzuki, 2015). GBS was proposed by Schank who once provided his dynamic memory model (Schank, 1983) as the theorical base for the initial CBS systems (Kolodner, 1983; Lebowitz, 1983).

According to Shank et al. (1999), GBS is composed with seven essential elements: Goal, Mission, Cover Story, Role, Scenario Operations, Resources, and Feedback. Figure 2.9 (Translated from Nemoto and Suzuki, 2004) depicts the seven elements and their relationship.

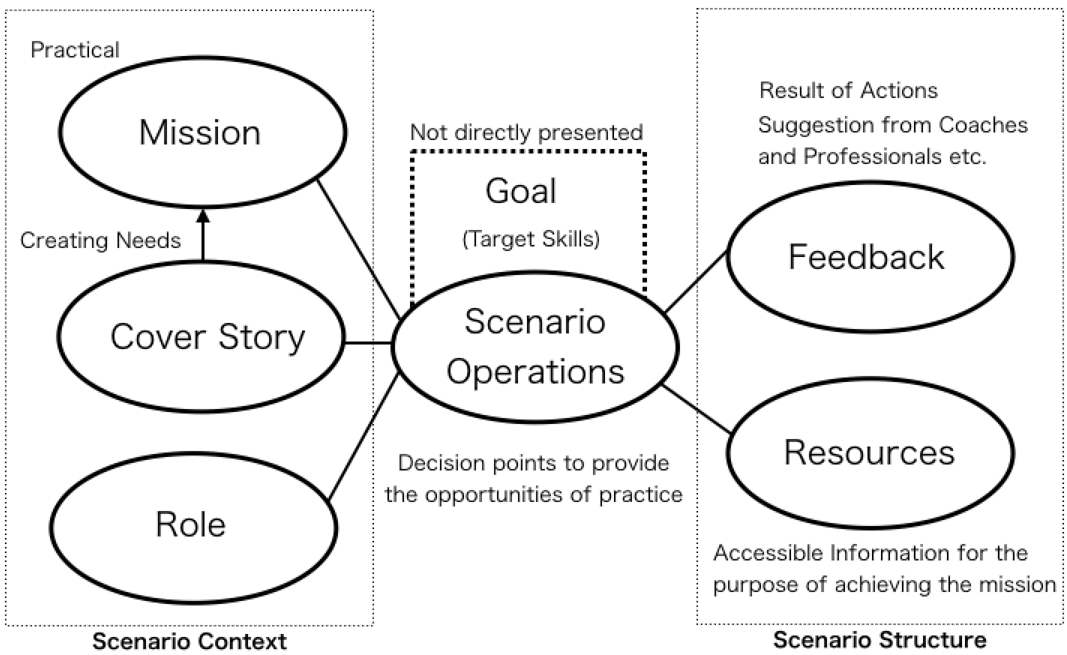

Figure 2.9. Components of GBS (Translated from Nemoto and Suzuki, 2004)

GBS design begins with setting clear goals for the learners, which generally falls into two knowledge categories. The first one is process knowledge which is the knowledge about how to practice skills. The second one is content knowledge which is the information required to achieve the learning goals (Schank et al., 1999). The mission is the problem that learners are expected to solve using skills they need to learn (Hsu and Moore, 2010). The mission must be motivating to the learners (Schank et al., 1999). For that reason, cover story provides the learner an important role so that they feel motivated to accomplish their mission (Suzuki, 2015).

The scenario operations are the descriptions that the learners actually do in order to achieve the learning goals. These operations are often accompanied by a learner's decision, which demonstrates what the learner has been learning. The learner's decisions are then evaluated and feedback is given to push the learner closer to accomplishing the given mission (Hsu and Moore, 2010).

2.4 Computing Education

Aptil et. al. (2018) states that while considerable number of researches have been done for making computing education easy for variety of learners such as computer science (CS) students (Fincher, 2015; Izu et al., 2016; Tan et al., 2009), end-user programmers (Dorn and Guzdial, 2010, 2006; Kery et al., 2017; Ko et al., 2011) and professional programmers (Albusays and Ludi, 2016; Brandt et al., 2009; D'Angelo and Begel, 2017), a large focus of these research projects has been for the learners who actually write code, and for the students in the class room (Tan et al., 2009) or professionals in industry (Albusays and Ludi, 2016).

Numerous studies in human-computer interaction (HCI) have contributed to understand the challenges of novice programmers (Andrew J. Ko et al., 2004; Guzdial, 2004; Kelleher and Pausch, 2005), proposed easy-to-use development environment

(Myers et al., 2004; Pane et al., 2002), and even invented new programming languages (Resnick et al., 2009) and visual programming tools (Myers, 1986; Shu, 1988). While these researches provided insights into the straggles to learning programming, many of them assume that learners are professional programmers (Li et al., 2015; Roehm et al., 2012)or end-user programmers (Lieberman et al., 2006) who will eventually write code.

Momentum around the importance of programming education (Rushkoff, 2010) has promoted studies on non-traditional programmers such as elementary school students and students outside computer science (Cellan-Jones, 2014; Forte and Guzdial, 2005; G. Wilson, 2006) so that they not only enhance computational thinking (Tedre and Denning, 2016; Wing, 2006) but also attain the skills to solve their domain specific problems (Burnett and Myers, 2014; Nardi, 1993). It is not until recently that some researchers have started looking into informal learning process among non-traditional populations such as designers (Dorn and Guzdial, 2010), high school teachers (Ni and Guzdial, 2012), and older adults (Guo, 2017). Along with this increased diversity in learning needs, recent studies (Chilana et al., 2016, 2015; Wang et al., 2018) found a unique class of learners who are motivated to learn programming, but never need to write code. This class of learners was termed conversational programmers (Chilana et al., 2015), which will be described in detail at the end of this section. Chilana (2016) argue that we know little about conversational programmers in today's software industry beyond the classroom study and informal discussions by practitioners ("How Much Code Should A UX Designer Write? – UX Mastery," n.d.; "Paul Ford: What Is Code? | Bloomberg," n.d.).

In this section, we are going to review the literatures that focus on non-traditional learner populations in human-computer interaction (HCI) for the learning and teaching programming has been a key research theme in HCI and computing education research for over three decades (Myers and Ko, 2009).

2.4.1 Formal Learning Environments for Programming

Formal learning is defined as an activity which has structured learning curriculum carried out with a fixed schedule normally in a school or workshop (Tan et al., 2009; Wang et al., 2018). Several studies revealed the fact that not all non-CS students who take basic CS courses do not want to become professional programmers, and such a basic courses fails to engage non-CS students (Chilana et al., 2015; Forte and Guzdial, 2005; Urban-Lurain and Weinshank, 2000).

In order to address such a failure, several researches have taken a learner-centered approach (Guzdial, 2015) and have provided formal learning environment to the non-CS students (Forte and Guzdial, 2005; Goldman, 2004; Guzdial, 2003; Guzdial and Forte, 2005; Marks et al., 2001). For example, an introductory media computation course which teaches programming not directly but by providing a practical application such as manipulation of image files was offered to non-CS students (Guzdial, 2003; Guzdial and Forte, 2005). Another attempt was a non-programming introductory course for computer science via natural language processing and AI (Lee, 2002).

Massive Open Online Courses (MOOCs) is also gaining its popularity as a formal learning environment among non-technical adult learners (Fitzpatrick et al., 2017; Zhang and Zheng, 2013). Another emerging formal learning environment includes bootcamps where the learners can learn programming by going through intensive curriculum within a short period of time. However, some doubts are raised to bootcamps and MOOCs if they really work or not for the people whose aim is to increase their market value as a professional programmer in the competitive labor market (James, 2017; Thayer and Ko, 2017).

2.4.2 Informal Learning Environments for Programming

Informal learning is defined as an activity which is self-directed by the learner without a structured curriculum. It is often initiated by the needs on the job (Marsick and

Watkins, 2001; Sonnentag et al., 2005). In this informal learning context, much attention has been paid to investigate how people learn programming online (Wang et al., 2018). For example, some studies have been done to understand why and when people can learn effectively with online interactive tutorials (Harms et al., 2016; Kim and Ko, 2017; Lee and Ko, 2015). While these online tutorials are useful for professional programmers and end-user programmers, they are rarely optimized for non-technical people (Wang et al., 2018).

Another type of informal learning is found in the use of discussion forums for novice programmers (Brandt et al., 2009; Lu et al., 2016). While such forums successfully facilitate the question and answer sessions (Lu et al., 2016; Nasehi et al., 2012; Scaffidi et al., 2012), the user identification and type of forum affects how much the participants take the advantage of the forum (Fincher, 2015; Marks et al., 2001).

2.4.3 Studies of Non-Traditional Programmers

End-user programmers are non-traditional programmers who write code not to develop a software as a professional programmer but to solve a domain-specific problem or to improve their productivity in a specific domain (Ko et al., 2011). The population of end-user programmers is estimated to be much larger than that of professional programmers (Scaffidi et al., 2005). For example, computer musicians, web designer, and data scientists write scripts to meet their domain-specific needs, and they often learn how to write scripts by a trial and error fashion (Burlet and Hindle, 2015; D'Angelo and Begel, 2017; Dorn and Guzdial, 2010; Izu et al., 2016) often by consulting books, code examples, technical blogs, and forums (Dorn and Guzdial, 2010, 2006).

Elementary school, junior high school, and high school teachers who teach CS to their students are another group of end-user programmer. They learn programming on the job (Ni et al., 2011; Ni and Guzdial, 2012). Guzudial (2015) states that CS teachers need to develop CS teacher identity (Ni, 2011) because teachers who express a teacher identity are more likely to be retained, more likely to join a professional organization, and more likely to seek out more professional learning opportunities (Luehmann, 2007).

2.4.4 Conversational Programmers

The term, "Conversational Programmer", was coined by Chilana et al. in the study of perceptions of non-Computer Science majors in intro programming (Chilana et al., 2015). The study found the existence of a class of people who do not necessarily want to be professional programmers or even end-user programmers who use programming to assist their main work but want to learn programming so that they can participate in the technical discussions with programmers and raise their value in the job market in the software industry (Chilana et al., 2015). This study was done over 75 business professionals who were the students of the management engineering program and enrolled in an introductory programming course at a large American university.

After the conversational programmers were first found in the university environment, the next research question was to investigate if they exist in practice outside the school environment. The research target were the business professionals who had not coded or seldom wrote code. 3151 survey responses were collected from a large multinational software company and found 42.6% had invested their time to improve their computer programming literacy (Chilana et al., 2016). Their two top motivations were to improve the technical conversations and increase their marketable value. In this study the existence of conversational programmers and their characteristics are empirically proved in a large-scale context.

al conversations Wang et al. carried out interviews with 23 conversational programmers (Table 2.1) and found that conversational programmers often did not know where to even start the learning process and ended up using materials which were not suited for them (Wang et al., 2018).

Table 2.1

Self-Identified Conversational Programmers Represented a Diverse Range of Occupations (Wang et al., 2018)

Age	Occupation	Age	Occupation
31-40F	entrepreneur	19-30M	product manager
19-30M	visual designer	19-30F	HR coordinator
41-50F	bank clerk	19-30F	university administrative staff
41-50F	HR coordinator	19-30M	marketing assistant (intern)
19-30M	helpdesk support (intern)	41-50M	product manager
51-60F	pharmacist	31-40F	humanities scholar
19-30M	business development manager	19-30F	artist
19-30M	marketing coordinator	31-40F	marketing coordinator
19-30F	advertising manager	19-30M	business assistant (intern)
31-40F	health scientist	51-60F	medical instructor
19-30F	library archivist	31-40F	psychologist
19-30M	business assistant (intern)		

In order to better understand the challenges conversational programmers face in technic Six reasons for feelings of failure among conversational programmers when modern learning resources are revealed but how to address this issue is still left open as an open research topic.

2.5 Summary

Educational research has a long history and has been done by psychologists, sociologists, biologists, brain scientists, instructional designers, computer scientists, and so many other people who are involved in an educational program in a specific context. It is literally impossible to cover all the educational studies done in the past in this chapter. For example the studies about ID models between 2000 and 2016 within a scope found 148 articles and identified 19 new ID models (Donmez and Cagiltay, 2016). Instead of trying to review all the studies, we reviewed the literatures historically important in the context of our study. For other specific literatures, we will review them as they are need in other chapters.

CHAPTER 3:
RESEARCH METHOD AND EVALUATION

3.1 Overview of Research Method and Evaluation

Emerging technologies such as AI and CPS are so new and relatively fast-growing that we rarely find structured learning materials suited for emerging technology even for technical people. Therefore, we first created story-based learning materials and validated their effectiveness in order to build a scaffold for this study. Then, we compared the difference between them in terms of the story-building methods.

We classified the learners into two categories; non-technical people and technical people, and designed the courses for adult learners in these categories. Also, we explored the difference between the on-line and off-line environments. Figure 3.1 depicts the strategy of research method deployed for this study.

The difference between the features of two different story-building methods is the new information which cannot be found in the study of a single story-building method but found only when the two studies are compared.

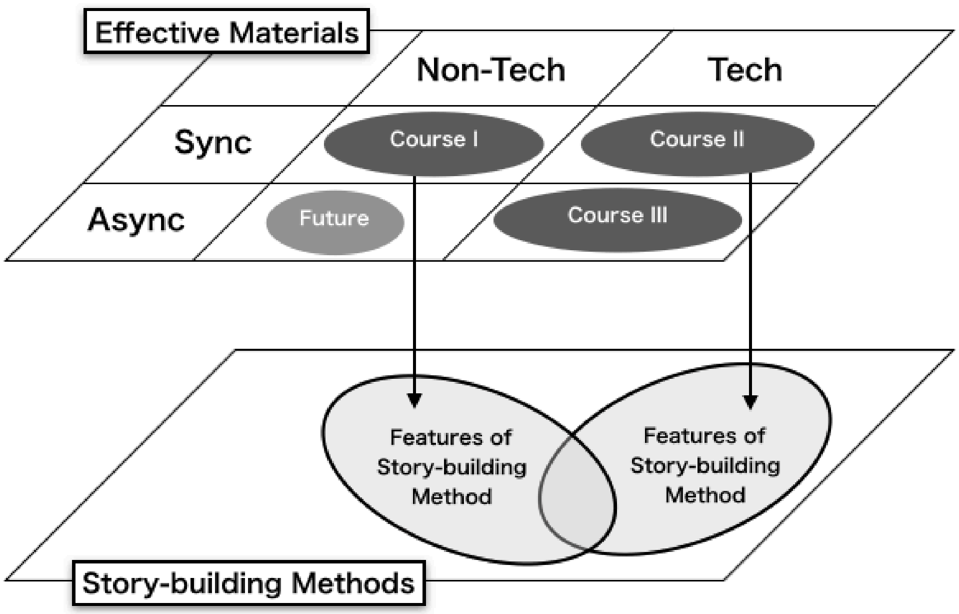

Figure 3.1. Research Method

Therefore, the novelty of this research is that the proposal of perspectives that reveal the differences in the stories used for emerging technology education and that we have identified the effective story features suited for non-technical adult learners. We also examined the possibility of leveraging of such differences in solving the issues that non-technical people called the conversational programmers are facing.

3.1.1 Building Effective Learning Materials

Three emerging technology courses were created for different classes of people as depicted in Figure 3.1. They are all story-based learning materials expected to be effective for the target learners proposed in this study, which will be explained in detail in the following sections. Course I was designed for non-technical adults and Course II and Course III for technical people. The main difference between Course II and Course III is the learning environment; Course II was designed for off-line environment and Course III for online environment in order to explore how the difference affects the learning. Table 3.1 is the summary of the target learners and learning environment which this study covers.

3.1.2 Identify and Evaluate the Story-building Methods

The deployed story-building methods for Course I and Course II were identified first, and then evaluated by checking the implementation of the courses as the results of the identified methods (Figure 3.2). This process is necessary to validate a story-building method deployed for each course.

Table 3.1

Course List

Course	Target Learner	Learning Environment
Course I	Non-technical Adults	Off-line
Course II	Technical People	Off-line
Course III	Technical People	On-line

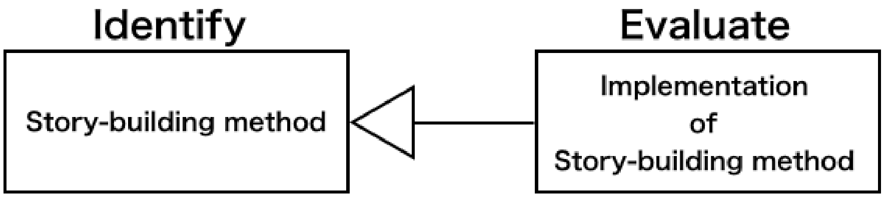

Figure 3.2. Validation of Story-building method

3.1.3 Structure of the Following Sections

The first following three sections are dedicated for the validation of effective learning materials in the following order. These sections correspond to Course I, Course II and Course III respectively:

1. Building learning materials for non-technical adults
2. Building learning materials for technical people
3. Building online learning materials for technical people

The following sections after the sections above are dedicated for identifying and evaluating the story-building methods in the following order. These sections correspond to the story-building methods of Course I and Course II respectively:

1. Building learning materials for non-technical adults
2. Building learning materials for technical people

3.2 Building Learning Materials for Non-Technical Adults

The purpose of this section is to propose an effective story-based course for non-technical adult learners who want to understand AI. In order to make non-technical adult learners feel that they understand the technology of AI enough to participate in a technical discussion and engender reasonable expectation of success so that they feel they will be able to understand this technology, this study proposes a story-based visual and agile teaching method with real tools and environment which professional engineers use. By doing so, the learners are expected to experience the authentic process and feel the accomplishment of building a neural network by themselves by the end of the course.

3.2.1 Proposed Method

This study challenged to overcome three issues. (1) Non-Technical adults might not be able to understand programming at all. (2) It becomes difficult to understand concepts and mathematical equations if learners cannot implement them. (3) Learners might lose their learning motivation if they cannot complete the given tasks.

The following methods (Method 1, Method 2, and Method 3) are deployed to solve these issues.

1. Method 1: Learning programming through real-life stories

Adult learners have more real-life experiences than young students at school have. For example, we could assume that adults have tax pay experience in real life. Therefore, for adult learners, it is possible to bring such real-life examples in the lecture and to provide an authentic story which aligns with learners' experience.

The better the storytelling of given programming code, the easier it becomes to understand what is written in the code. Figure 3.3 is an example of such a code. It is highly possible for the learners to guess what is written in the code correctly because the learners can read such a story-based code as if it is a normal story which they would find in a book. To validate if the guess is correct, the learners can run the code to see if they get the expected result. This process promotes self-directed learning attitude which aligns with the characteristics of adult learners (Merriam, 2001).

```
# Sales Tax Calculation
# True sales of the product: $350, sales tax: 7%
tax = 0.07
price = 350 * ( 1 + tax )
print('Total payment = ', price)

Total payment =  374.5
```

Figure 3.3. Code with Good Storytelling

By the strategy above, this study tried to resolve the first issue, “The non-technical adults might not be able to understand programming at all.”

2. *Method 2: Implementation of concepts with the help of visual clues*

Usually, it is not easy to use a real-life story as a metaphor to explain highly abstracted mathematical concepts and algorithms. Also, there are several ways to implement such concepts and algorithms. Therefore, it is difficult for a novice programmer to implement them from scratch.

In order to cope with this type of difficulty, this study proposes to prepare uncompleted implementations and let the learners focus on filling the blanks to complete the implementation. With this method, the uncompleted implementations are prepared with the visual clues between the abstract concept and its implementation to help the learners find the link between them by themselves.

Figure 3.4 is an example of the mathematical equation (i.e., highly abstract concept) and its implementation. It is presented with visual clues which help the learners find the link between them. The learners could see the link between the symbol ‘ α ’ in the equation and the variable ‘alpha’ in the program. Likewise, they could see the link between the symbol ‘ Σ ’ in the equation and the function ‘sum’ in the program. With a help of such visual clues, the learners could find the answers described as ‘????’ in the program by themselves.

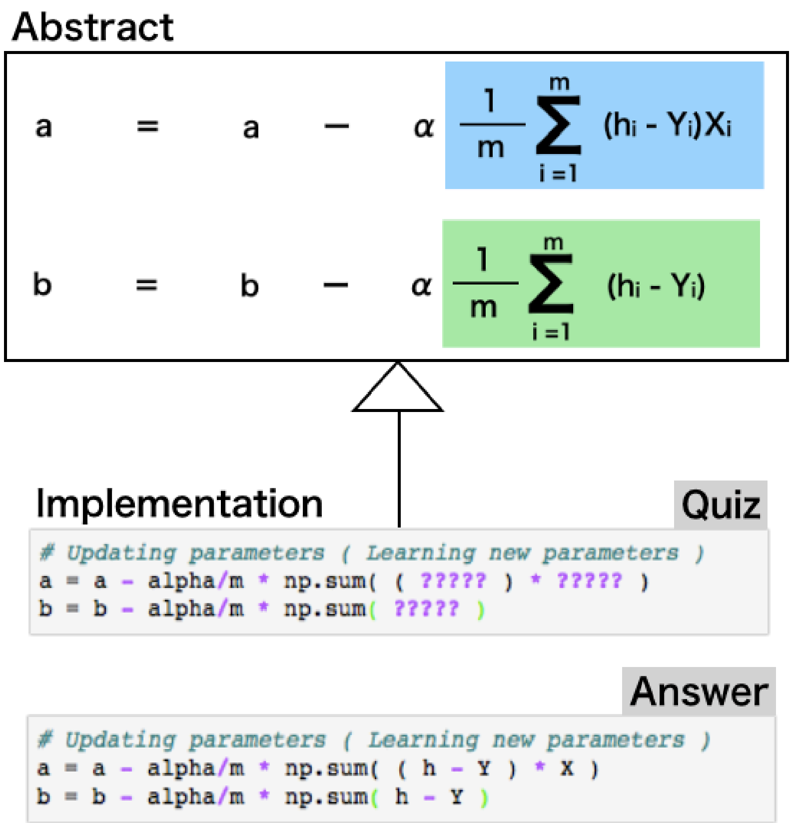

Figure 3.4. Visual clue between the abstraction and its implementation

By the strategy above, this study tried to resolve the second issue, "It becomes difficult to understand concepts and mathematical equations if learners cannot implement them."

3. Method 3: Managing the learning tasks with small agile steps

The agile method was born in 2001 with Agile manifesto and practices in the context of software development (Fowler and Highsmith, 2001). One of the essences of the agile method is the flexible attitude toward the unknown future. The agile method promotes the behavior of many small trials to find the right way to solve problems. If learners are unsure if they understand the learning objectives correctly, they can try their thought and correct it if it happens to be wrong. This process is very similar to the process proposed in the agile method as the agile manifesto says it is a good practice to find the working solution by doing.

Storytelling tasks and visual feedback help the learners find a way to correct their thoughts in an agile way. It is also easier to set the difficulty level of the tasks to be appropriate for the non-technical adult learners when the tasks are designed in the context of agile small steps. If the learners are allowed to make challenges iteratively under such a context described above, the process of clearing a given task itself will have a game-like characteristic.

In order to enjoy this type of game, it is necessary to provide a learning environment where the learners are allowed to work on the learning tasks in a try and error fusion. In this study Jupyter Notebook (“Project Jupyter,” n.d.) is provided, which is an open-source environment. Jupyter Notebook is composed of two types of cells. A code cell is where the code is written and executed, and a markdown cell is where the texts and images go in for the purpose of documenting the story attached to each learning task.

The code put into a code cell can be executed anytime. Since code cells can be created as many as learners want, the learners can leave several code cells as the history of their work. This feature allows the learners to work on the learning tasks in a try and error fashion and therefore it realizes the aim of the teaching method to make a learning task game-like.

By the strategy above, this study tried to resolve the third issue, “Learners might lose their learning motivation if they cannot complete the given tasks.”

3.2.2 Evaluation Method

This study designed a basic AI course for non-technical adult learners as a blended course using the proposed teaching method. The summary of the evaluation method is depicted in Figure 3.5.

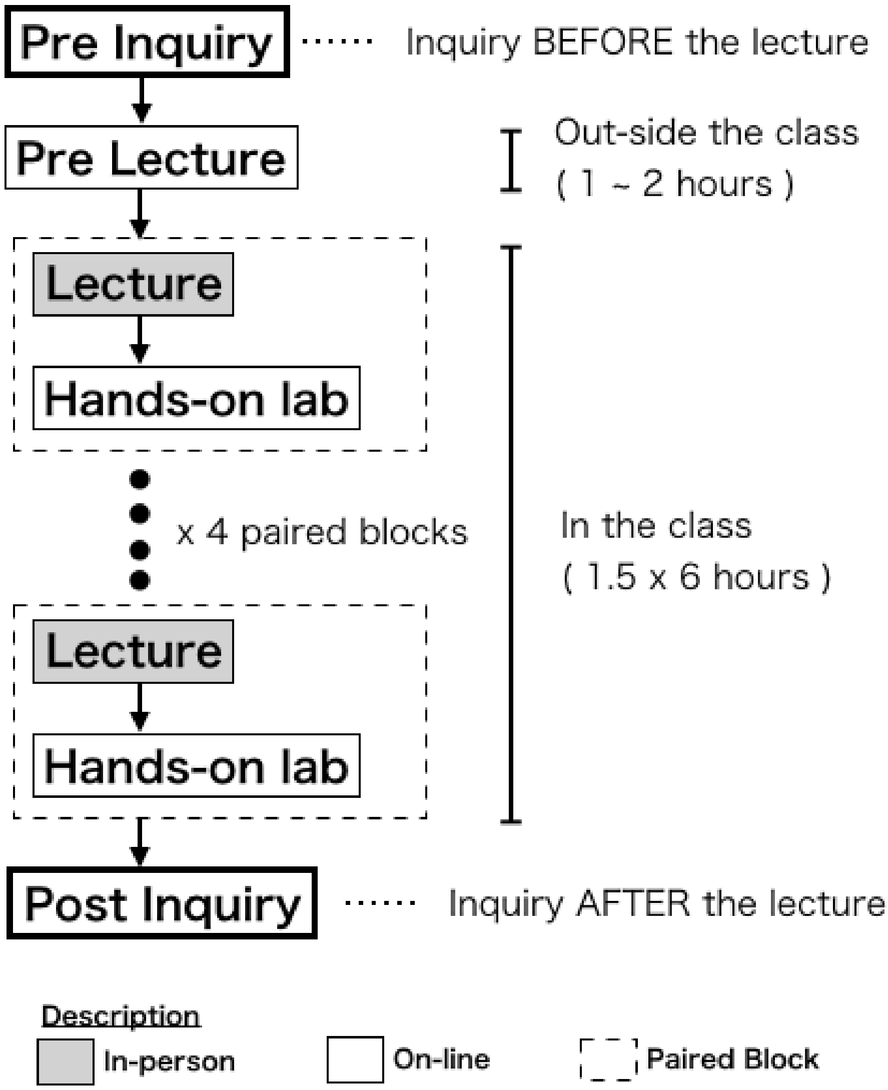

Figure 3.5. The flow of the AI lecture

In this course, the participants were asked to take an online lecture to study the minimum amount of programming and mathematics required to understand the first lecture conducted in the class. Lectures were provided in the class i.e. off-line, and hands-on labs were provided online using Jupyter Notebook. A hands-on lab was provided followed by a lecture associated with it (i.e., they are paired). We created six paired blocks and participants were asked to work on small hands-on labs by themselves so that the participants could go through the course in a small step-by-step fashion and built a neural network in the end by themselves.

Since each paired block was designed as a 1.5 hour-long block, it was possible to provide the whole lecture within a day. The titles of six lectures were as follows: 'History of Artificial Intelligence', 'Linear regression', 'Logistic regression', 'Multi-Classification', 'Image Representation', and 'Neural Network.'

The effectiveness of the proposed teaching method was evaluated by the quantitative analysis and the qualitative analysis over the participants (Appendix A and B). Table 3.2.1 shows the list of questionnaires used in this study. Responses were given on a five-point ordinal scale, ranging from - 2-"disagree," to +2-"agree," with 0 representing "neither agree nor disagree". Participants were asked to answer the same question before and after the lecture in the class.

Table 3.2.1.

List of Questionnaires

	Learning Effectiveness
e01	Can you explain how Artificial Intelligence works to other people?
e02	Can you program Artificial Intelligence by yourself?
	Visual Method Effectiveness
e03	Do you think the visual aids such as graphs and images, which you were provided as you went through the class materials, supported your understanding of learning objectives?
	Agile Method Effectiveness
e04	Do you think it is a good lecture style to take a lecture and do a hands-on lab in a parallel fashion?
	Expected Success (Expectancy-Value Theory)
q01	In the future, do you feel you will be able to understand AI deeply with confidence?
q02	In future, do you feel you will not be able to follow the lecture for understanding AI?*
q03	In the future, do you feel you will be able to understand the lecture for understanding AI?
q04	In the future, do you feel you will receive a good grade in understanding AI?
q05	In the future, do you feel you will be not able to understand AI? *
q06	In the future, do you feel you will be not good at understanding AI? *

*Negative Question

The expectancy-value theory (Wigfield and Eccles, 2000) says that the expected success predicts how well the learners will perform on the subject, and the value of the subject predicts if the learners will continue to make an effort on learning the subject. Therefore, this study evaluated the proposed teaching method based on this theory to evaluate how well the participants will perform. To create the list of question items to measure the expected success, we took the question items (q01~q06 in Table 3.2.1) created by Ichihara and Arai (Ichihara and Arai, 2006), which was originally designed to measure the expected success for the students learning mathematics, and replaced 'mathematics' with 'AI' to measure how confident the students are about understanding AI before and after the lecture.

In this study, in order to analyze the effectiveness of agile method, the participants were requested to answer the question item e04 in Table 3.2.1 and asked its reason in a free format. The open-coding method (Kobayashi et al., 2018b) was used to analyze free descriptive answers with the following procedure:

Step 1: View the free answers, and pick those are related to the three issues this teaching method tried to solve and learners' success expectation for understanding AI. The viewpoint set as "solving the three issues" and "learners' success expectation obtained in this course" for Affinity Diagram grouping, in order to evaluate solving the three issues and increasing learners' success expectation.

Step 2: Look for, from the aforementioned viewpoint, the descriptions relate to structuralizing with multiple viewpoints, and sort them into groups.

Step 3: Write titles for each group that summarizes the essence of the group, at a slightly higher level of abstraction (called "Open coding results" in this study)

In order to ensure the reliability of the open-coding result generated by the first author, we validated the result with an open-coding specialist (Golafshani, 2003).

Table 3.2

Profile of participants

Programming expertise	Number of Participants
No Experience	58
Entry level	24
Junior level	6
Senior level	2

Age	Number of Participants
20 ~24	3
25 ~ 29	2
30 ~ 34	3
35 ~ 39	14
40 ~ 44	24
45 ~ 49	23
50 ~ 54	19
55 ~ 59	2

Job Role	Number of Participants
Manager	11
Clerical Work (Human Resource, General Affair, Account, Communication)	14
Sales	12
Marketing	7
Strategic Marketing Planning	11
Strategic Engineering Planning	10
Engineer	9
Other	16

3.2.3 Evaluation Result

The participants in this lecture were business professionals coming from a wide range of industries, ages, job roles, and different levels of programming skill. In this study, a business professional is defined as a person who has a job in a company. Table 3.2 summaries the profiles of participants.

From the 90 participants above 75 target participants were selected as non-technical adult learners by removing participants who played engineer role in the office and who had a junior or senior level of programming expertise because they were close to technical professional in terms of their programming expertise although she or he served a non-technical role in the office.

Table 3.3

Participants' confidence about AI after the lecture

ID	**Paired Differences**					t	df	P value (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
e01	-3.39	1.304	0.151	-3.69	-3.09	-22.5	74	***
e02	-1.75	1.326	0.153	-2.05	-1.44	-11.4	74	***

*** Significant at P<0.0001

On the other hand, we removed all the participants who take engineer role in the office even though they claimed themselves to belong to ‘No Experience’ and ‘Entry level’ because they might underestimate themselves.

4. Result 1: Learning Outcome

The learning outcome was evaluated by the question item e01, ‘Can you explain how Artificial Intelligence works to other people?’ and the question item e02, ‘Can you program Artificial Intelligence by yourself?’. These questions items are asked to the participants before and after the lecture.

Table 3.3 is a summary of a paired t-test over the question items, e01 and e02. The average score for the question item e01 before the lecture was -2.01 (standard deviation 1.32) and after the lecture was 1.37 (standard deviation 0.65). The average score for the question item e02 before the lecture was -2.84 (Standard deviation 0.52) and after the lecture was -1.09 (standard deviation 1.41).

5. Result 2: Effectiveness of Agile Method

The effectiveness of agile method was evaluated by the question item e03, ‘Do you think the visual aids such as graphs and images, which you were provided as you went through the class materials, supported your understanding of learning objectives?’, and by the question item e04, ‘Do you think it is a good lecture style to take a lecture and do a hands-on lab in a parallel fashion?'. These questions items were asked to the participants after the lecture.

Table 3.4 is a summary of the results over the question items, e03 and e04. Table 3.5 is the result of open-coding to analyze the reason for the answer e04 (i.e., the reason why the participants felt the agile method was effective).

Table 3.4

Participants' attitude about Visual and agile method

	minimum	**maximum**	**median**	**average**	**standard deviation**
e03	0	3	3	2.533	0.704
e04	-2	3	3	2.36	1.0

Table 3.5

The open coding result about the reason why the agile method works for non-technical adult learners

Open Coding Result	**Number of Sentences**
Actual programming experience improves my understanding of the subject.	34
Doing hands-on labs as soon as its lecture is presented helps me understand the lecture deeply.	27
Because the connection between the concept and what I'm doing in its hands-on labs becomes clear.	17
Above all it is fun, and I can learn independently in this way.	3

Table 3.6

Participants' success expectation change

ID	Paired Differences					t	df	P value (2-tailed)
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
q01	-1.35	1.19	0.138	-1.62	-1.07	-9.79	74	***
q02	1.17	1.78	0.206	0.764	1.58	5.71	74	***
q03	-1.2	1.52	0.175	-1.55	-0.85	-6.86	74	***
q04	-1.4	1.22	0.141	-1.69	-1.12	-9.94	74	***
q05	0.97	1.60	0.185	0.605	1.34	5.26	74	***
q06	0.85	1.35	0.156	0.542	1.17	5.46	74	***

*** Significant at P<0.0001

6. Result 3: Success Expectation

Table 3.6 is a summary of a paired t-test over the question items: q01, q02, q03, q04, q05, and q06, which were asked to the participants before and after the lecture. Since q02, q05, and q06 are negative questions, the negative answer to those questions means positive in terms of expectancy-value theory.

3.2.4 Discussion

The goal of non-technical adult learners like conversational programmers is not to write a code in the job but to improve their participation in technical conversations (Wang et al., 2018). From the result of question item e01, 'Can you explain how Artificial Intelligence works to other people?', found in the table 3.3, there is a large shift in the average score from the result before the lecture, 'disagree: -2.01', to the result after the lecture, 'agree: +1.37'. The difference was confirmed to be statistically significant in terms of the average value with P<0.0001. Therefore, it is reasonable to conclude that the participants gained the confidence to talk about AI to others.

As to the learning outcome about programming, from the result of question item e02, ‘Can you program Artificial Intelligence by yourself?’, found in Table 3.3, there is a large shift in the average score from the result before the lecture, ‘disagree: -2.84’, to the result after the lecture, ‘disagree: -1.09’. The difference was confirmed to be statistically significant in terms of the average value with $P<0.0001$. Knowing all the participants we analyzed in table 3.3 had no previous programming experience or had only entry-level expertise, there was some noticeable change in the participants’ attitude toward programming.

The result shows that the non-technical adult learners gained some level of confidence in programming skill set within a day-long course designed by the proposed teaching method. Therefore it is also reasonable to conclude that the effectiveness of this teaching method for the first issue, “the non-technical adults might not be able to understand programming at all”, and the second issue, “it becomes difficult to understand concepts and mathematical equations if learners cannot implement them”, because it is hardly possible to say, “I can program AI by myself”, if learners do not possess some level of confidence in programming.

The effectiveness of the visual method for non-technical adult learners is shown in Table 3.4 as the result of question item e03, ‘Do you think the visual aids such as graphs and images, which you were provided as you went through the class materials, supported your understanding of learning objectives?’. Its highly positive average score, 2.53 (standard deviation 0.7), suggests that visual method was well accepted by the participants and affected positively in supporting participants’ learning process.

The effectiveness of the agile method for non-technical adult learners is shown in Table 3.4 as the result of question item e04, ‘Do you think it is a good lecture style to take a lecture and do a hands-on lab in a parallel fashion?’. Its highly positive average score, 2.36 (standard deviation 0.95), suggests that the agile method was well accepted by the participants and affected positively in supporting participants’ learning process.

The reason why the participants thought the agile method deployed in this lecture worked well for them was analyzed by the open-coding method. The agile practice of learn-by-doing is appeared in the first category, ‘Actual programming experience improves my understanding of the subject.’, and the comments related to this category appeared 34 times. The agile practice of iterate-small-steps is appeared in the second category, ‘Doing hands-on practices as soon as its lecture is presented helps me understand the lecture deeply.’, and the comments related this category appeared 27 times. These results suggest that the agile method worked in the same way it works in software development.

The third category, ‘Because the connection between the concept and what I'm doing in its hands-on practice becomes clear.’, suggests that the participants understood abstract concepts and algorithms by actually implementing them. We could see that the agile method played an important role for participants to find and understand the link between concept and its implementation. The last category, ‘Above all it is fun, and I can learn independently in this way.’, suggests that the adult learners were self-motivated and enjoyed the learning process. This is one of the desired effects that this study planned to incorporate in the lecture by introducing the agile method in the proposed teaching method.

The effectiveness of the teaching method proposed in this paper appears in table 3.6 with the question items about the expected success in understanding AI. All the paired differences in the table were confirmed to be statistically significant in terms of the average value with $P<0.0001$. This change in the participants’ attitude within a day-long lecture suggests that non-technical adult learners gained positive feeling that they could successfully understand this complex AI technology in future, which is one of the key drivers for the learners wanting to continue to learn AI technology as the expectancy-value theory predicts, and which was the goal of this lecture designed by the proposed teaching method.

3.3 Building Learning Materials for Technical People

The Cyber-Physical Systems (CPS) is difficult to learn. There are many reasons for that. First of all, it is a very challenging genre because the CPS is a cross-sectional technology (Figure 3.6). It demands the learners to get familiar with many related topics, understand how they are related each other, and learn the technologies deep enough to implement the ideas.

Things become much worse for the educators because they have to cope with the following problem: "All learners not only have different learning objectives but also their objects change as they deepen the knowledge". Therefore, the educators need to guide the learners throughout their entire learning cycle. This kind of thinking must be born naturally in educators' mind when the learners are expected to keep learning the CPS.

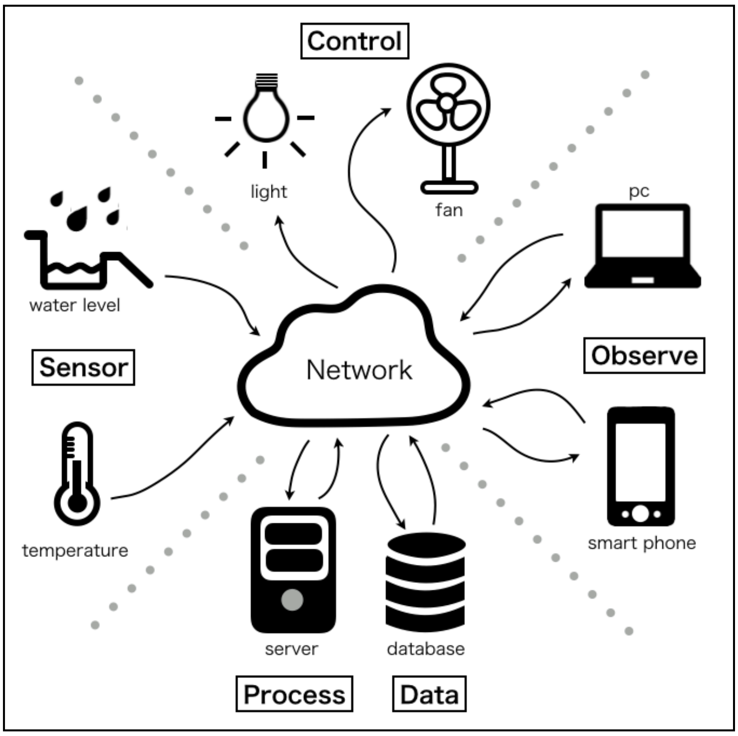

Figure 3.6. CPS is a cross-sectional technology

It is possible for the educators to provide a very special educational system tuned for each learner's needs. However, it is not cost effective and practical because it is not possible to know all the needs in advance. Therefore, the fundamental question here is how the educators can provide such a flexible educational system for CPS that can cover all the different learners' needs but yet very flexible even it faces to the changes of learners' learning objectives throughout the learners' learning cycle. This may seem like an unachievable idea, but in fact, there is a simple and effective strategy to approach this problem.

3.3.1 Proposed Method

4 Open-Closed Principle

Bertrand Meyer coined the famous Open-Closed Principle (OCP) in 1988, which this study can deploy to tackle our fundamental question. It says, "Software entities should be open for extension, but closed for modification". We can replace "Software entities" with "Teaching entities" to get our own version of OCP: "Teaching entities (sensors, actuators, network, etc.) should be open for extension, but closed for modification". "Open-for-extension" means that the teaching entities can be extended. In other words, we can change the behaviour of the entities. "Closed-for-modification" means that the extending the behaviour of the entities does not force any change to the existing entities. It would seem these two attributes are at odds with each other because the normal way to extend the behaviour of an entity is to make changes to itself.

Figure 3.7 shows the design of a simple educational system that does not conform to OCP. It is not closed for the extension because if the learners want to learn how to use a pressure sensor instead of a temperature sensor, they need to use a different educational system specially designed for that. This means the educators have to provide as many educational systems as the number of CPS topics they want to teach. This is practically impossible.

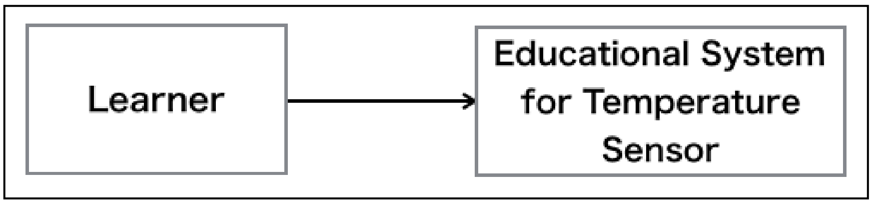

Figure 3.7. System Design against OCP

This system is not closed for modification either because if the educational system is modified, the learners need to learn how to use a modified system in order to access the modified features of the system.

What is the better solution then? The key is the abstraction. SysML allows us to create abstractions that are fixed and yet represent an unbounded group of possible behaviours. Figure 3.8 is the educational system design that conforms to OCP.

This system is closed for modification because the learners do not depend on a concrete system but depend on a common interface of the educational system for sensors that is stable (i.e. the interface won't change).

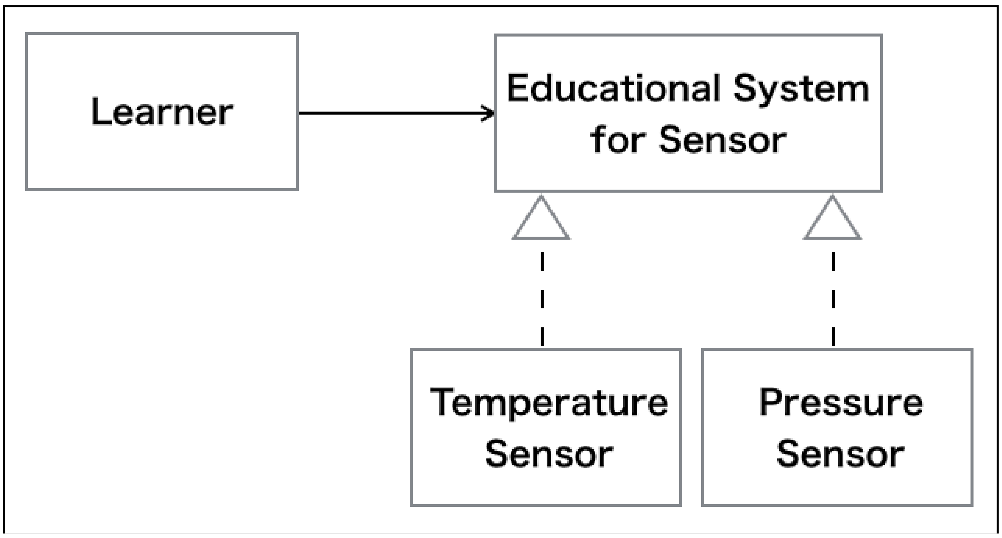

Figure 3.8. System design that complies with OCP

It is also closed for the extension because if the learners want to learn how to use a pressure sensor, they just need to replace "Temperature Sensor" with "Pressure Sensor" while the way to access to the sensor stays the same. The learners do not have to learn a new interface even though the learning object is changed from "Temperature Sensor" to "Pressure Sensor". This is good.

5 Educational System for CPS

Since the CPS contains not only sensors but also many other components (networks, actuators, etc.) we can go one step farther than Figure 3.8 with a help of "Aggregation" available in SysML. Figure 3.9 shows how it can be done. "Educational System for CPS" aggregates the teaching entities that the educators would want the learners to understand how to use them.

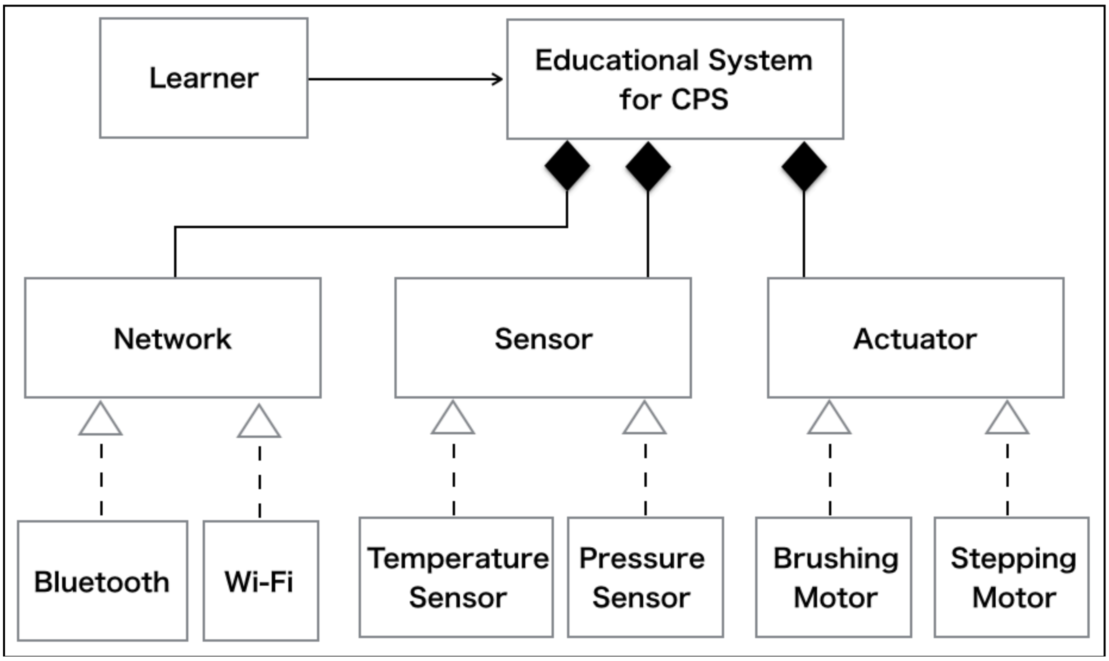

Figure 3.9. Architecture of Educational System for CPS

Educators are allowed to design "Educational System for CPS" of their own and let the learners stay with it throughout the learners' learning cycle. Once the learners get familiar with a specific learning system designed by the educator, they do not have to worry about learning another educational system each time they want to learn how to use a new CPS entity. The introduction of such a commonly usable educational system greatly reduces the total learning cost for learners.

6 Story-Based Learning: Building a Robot with the Educational System for CPS

"Educational System for CPS" could have as many CPS components as the user wants to have. However, it does not have any story among the components. It is possible to teach how to use each CPS component independently but if the educator can provide a story about how the components are related and communicating each other, it helps the learners to understand how they work together to achieve a purpose of the system as a whole. Most importantly it helps the learners to keep their motivation throughout their long learning cycle. Any story could be implemented with "Educational System for CPS". It's all up to the educators. In this study a story about building a robot is selected, which uses "Educational System for CPS" (Figure 3.10).

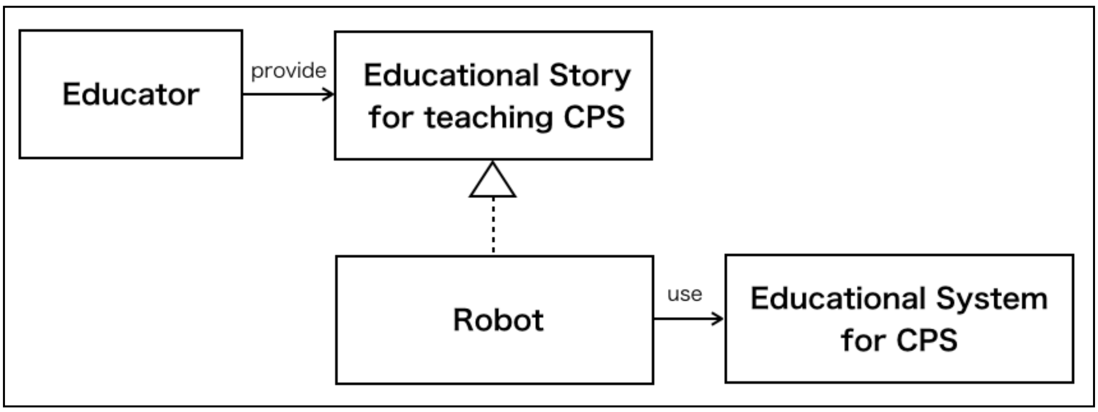

Figure 3.10. Robot as an Implementation of Educational Story

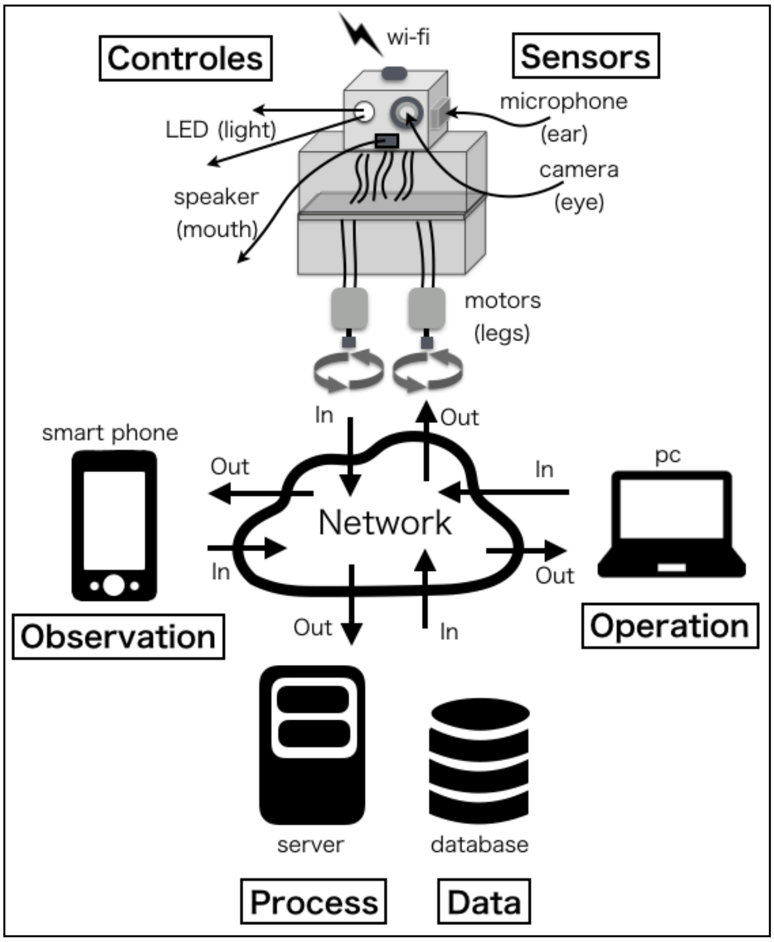

Figure 3.11. Robot with many CPS components

This study picked this story because building a robot naturally forces the learners to understand many CPS components as you see in Figure 3.11.

3.3.2 Evaluation Method

"Educational System for CPS" is an abstract entity. Therefore, we need to make it physically accessible for the learners. First of all, we evaluate if the proposed story-based method can produce a concrete course by implementing it with physical CPS entities. Then we evaluate if the produced course satisfies the needs of the target learners and the educators.

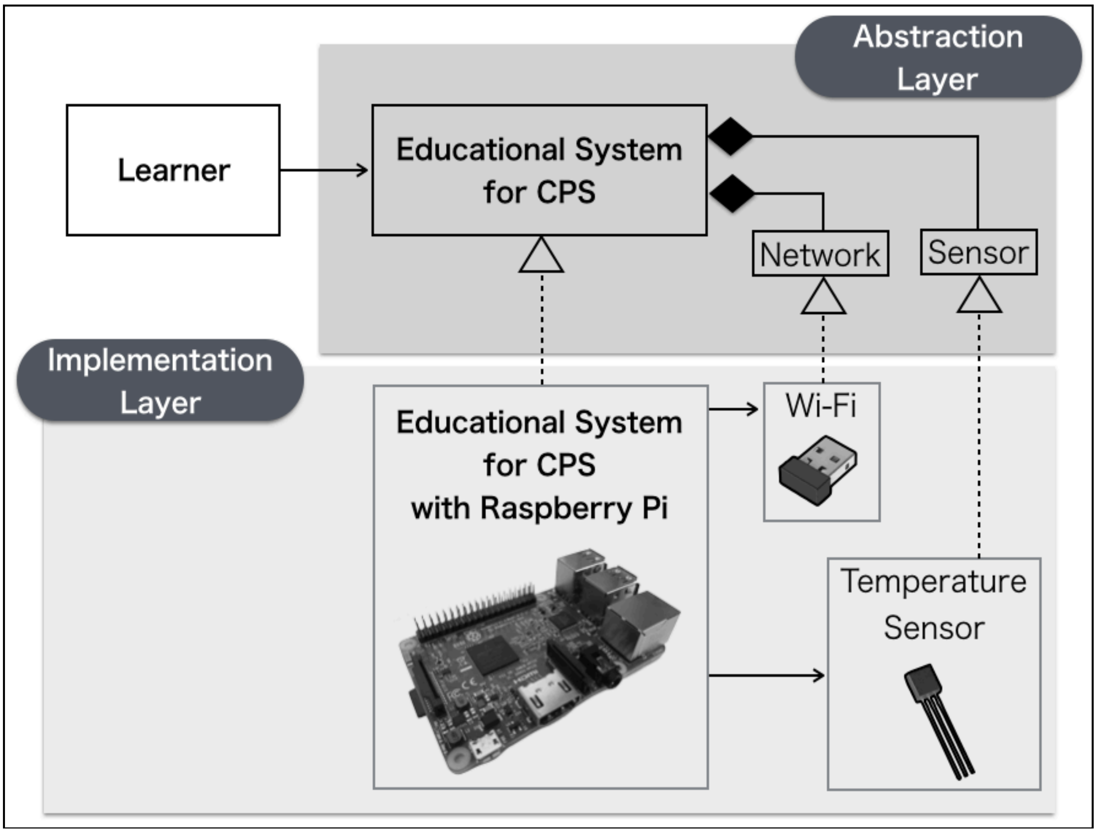

Figure 3.12. Raspberry Pi used as an Educational System for CPS

3.3.3 Evaluation Result

4 Implementing an Educational System for CPS with a Raspberry Pi

First of all, from Figure 3.9 it is clear that the instance of "Educational System for CPS" needs to have a way to hook multiple CPS entities. Also, it is desirable for the instance to provide an easy interface for the learners to access to CPS entities. To meet these requirements, this study selected a Raspberry Pi to implement "Educational System for CPS". Figure 3.12 shows how it was implemented.

Raspberry Pi (Figure 3.13) is a low-cost credit-card sized computer that has been widely accepted all over the world even in K12 schools due to its flexibility and simplicity. This computer has desirable features to implement "Educational System for CPS" for the following reasons:

- CPS devices can be hooked easily via its General Purpose Input-Output (GPIO) pins
- Both GUI and CUI interfaces are provided for learners
- Almost all computer languages are available
- Many open-source libraries are available.
- Multiple Operating Systems are supported (Linux, Windows, etc.)

5 Story-Based Learning

It is the educator's responsibility to create an interesting story for what they want to convey to the learners. Table 3.7 shows the brief description of the story-based learning scenario for building a robot, which this study practiced for both elementary school students and university graduates.

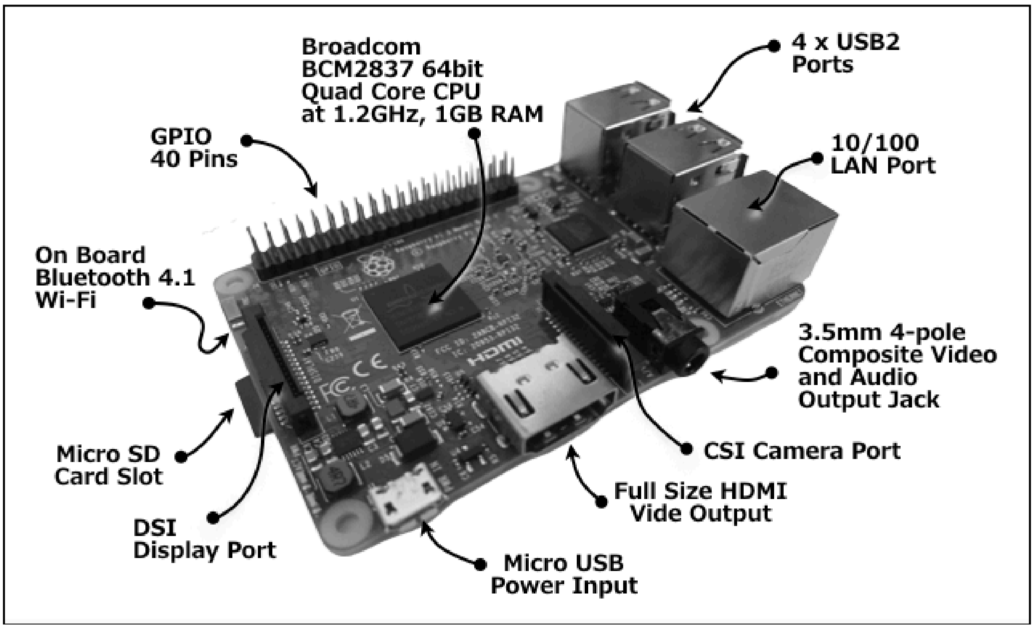

Figure 3.13. Raspberry Pi 3 Model B

Table 3.7

Story-Based Learning Scenario for Building a Robot

Step	Story	Purpose
1.	Use a Raspberry Pi for the first time	Install OS and start using Raspberry Pi as a computer
2.	Craft a program for the first time	Learn how to program using GUI blocks (Scratch)
3.	Flash an LED with a program	Learn how to use GPIO and control LED with a program
4.	Make a stand-alone robot environment	Make the robot stand-alone (i.e. no wired connections)
5.	Make legs	Attach and control motor devices
6.	Make eyes	Attach and receive video image from Web camera
7.	Make a mouth	Attach a speaker device and use the speech synthesis
8.	Make an ear	Attach a microphone and implement a voice recognition

We explain more details for each step below.

6 Story-Based Learning Scenario for Building a Robot

1. **Use a Raspberry Pi for the first time.**

   The students learn how to use a Raspberry Pi in this step. For the learners, this will be the base of the educational system for CPS. They start with installing OS of their choice (typically Linux or Windows) onto a Micro SD card (Figure 3.14). This way they understand the role of OS and how to set it up the system from scratch. It is a good idea to provide a nice GUI desktop interface so that the students can start using many interesting pre-installed applications right away.

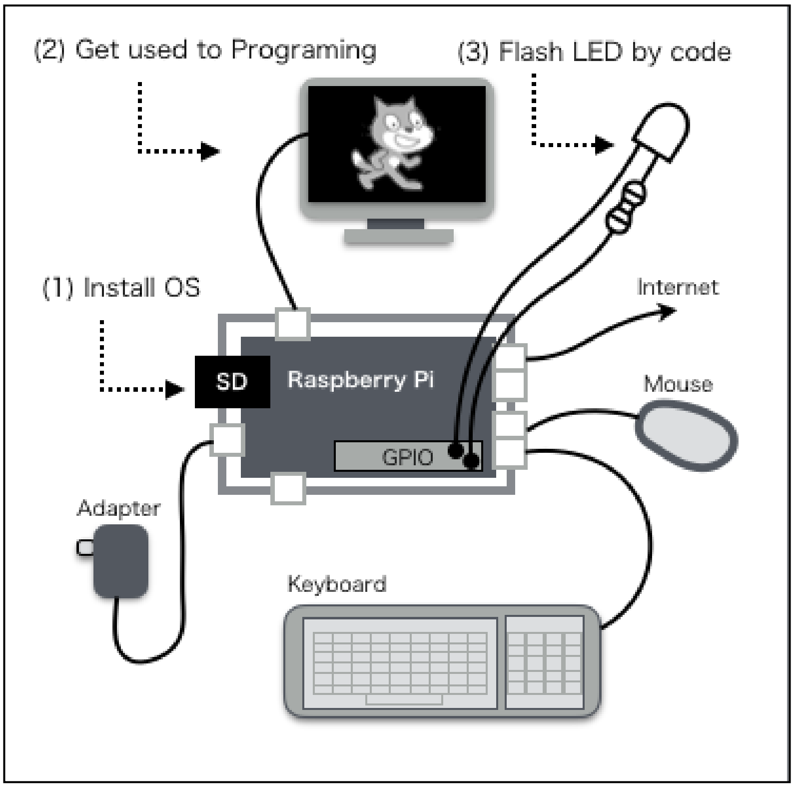

Figure 3.14. Raspberry Pi with the Initial Configuration

2. **Craft a Program for the First Time.**

   Scratch is a GUI based programming language created under a project of the Lifelong Kindergarten Group at the MIT Media Lab. Scratch is so intuitive that even 12-K school children could write their first program in few minutes with a proper guidance. Students can learn basic elements of programming effectively.

3. **Flash an LED with a Program.**

   By attaching an LED with an appropriate current resistor to GPIO pins, it becomes possible to control the LED be on or off. Since Scratch is capable of controlling the status of GPIO pins to be high or low, we can simply use Scratch to flash LED.

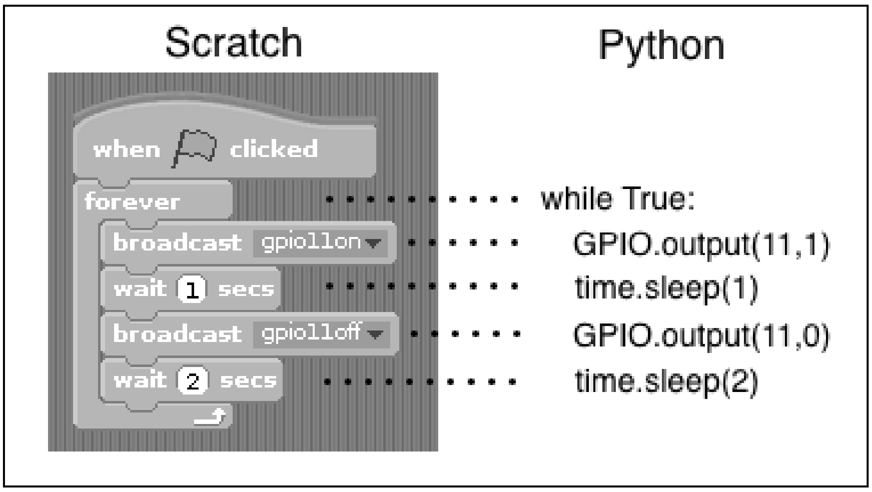

Figure 3.15. Line-by-Line comparison between Scratch and Python

Once the students understand how to flash LED with Scratch, they can smoothly move to a text-based programming language, Python because the line-by-line correspondence between the Scratch code and the Python code is very clear as you can see in Figure 3.15.

4. **Make a Stand-Alone Robot Environment.**

In order to make a robot freely movable, we need to remove wires that tie the robot to a monitor, a keyboard, a mouse, an Ethernet cable, and a power adaptor cable. Figure 3.16 shows how to remove the entire wires around the Raspberry Pi. We can remove a power adapter cable by replacing the power source with a mobile battery, which is commonly used as a smartphone recharger. The Ethernet cable can be removed as well by replacing the Internet access by enabling an on-board Wi-Fi (the latest Raspberry Pi 3 model B, has this option. If you have an old model you can use a USB Wi-Fi adapter instead.). Removing other wires is not as simple as it looks because we lose the access to the Raspberry Pi without a keyboard, a mouse, and monitor.

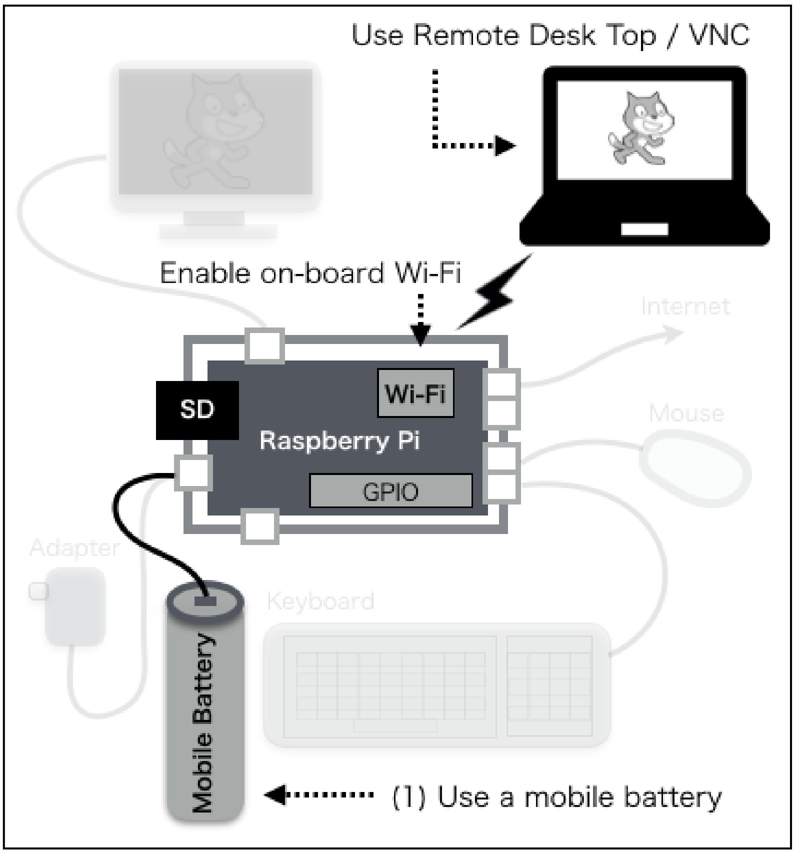

Figure 3.16. Raspberry Pi with a Stand-Alone Configuration

For the solution, we can use a remote desktop technology that allows us to access to the Raspberry Pi externally through the network. We can have the desktop screen image of Raspberry Pi on a PC that runs a remote desktop application (VNC is an alternative to a remote desktop technology).

5. **Make Legs.**

Many students enjoy making legs for their robot because they will learn not only programming about also building a mechanical part of the robot and make their robot move around through a browser-based controller from their own smartphone. Figure 3.17 shows an example of building legs. In this example, two motors are used to enable a right-left movement control independently. Note that we placed two motor drivers in between GPIO pins and motors. A motor controller is an electronic device that acts as an intermediate device between a microcontroller, a power supply or batteries, and the motors; you can buy a motor driver from electronic stores cheaply. Motor drivers are needed because the Raspberry Pi (the brain of the robot) cannot drive the motors directly due to its very limited power output capability. Motor drivers can provide the current at the required voltage but cannot decide how the motor should be controlled. Raspberry Pi and the motor drivers need to work together to achieve the motor control. In addition to the physical setup, we need to provide an interface for the motor control. Since we can run a web server on Raspberry Pi, we can use a web browser for that purpose.

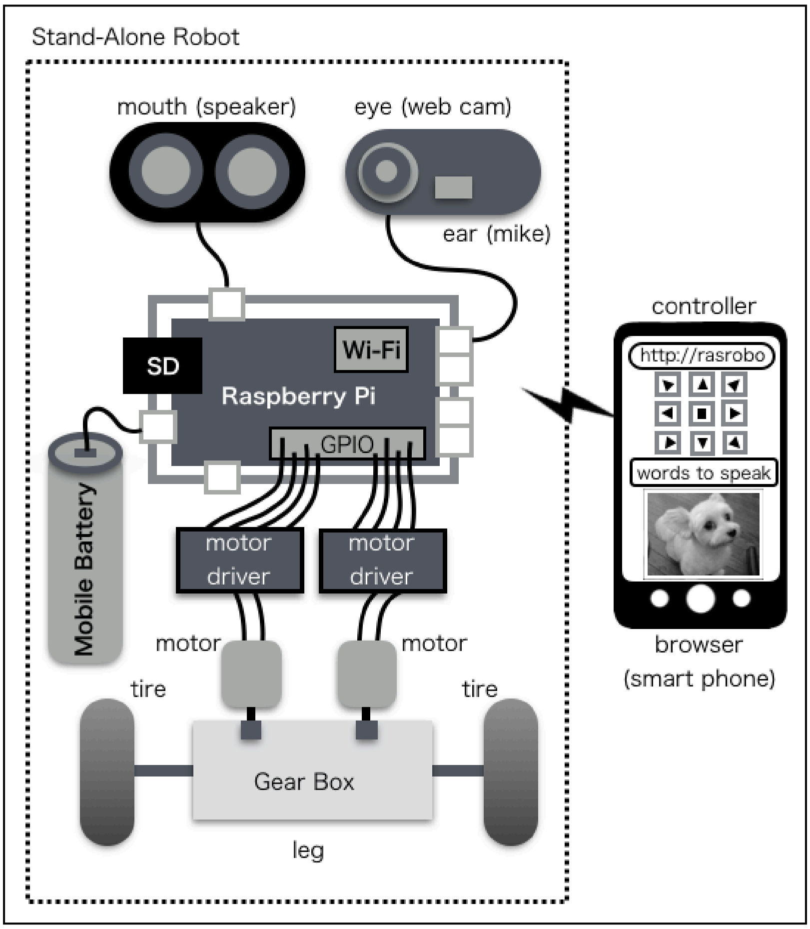

Figure 3.17. Stand-Alone Raspberry Pi Robot

There is an open-source software called, WebIOPi, which enables the GPIO control via a web browser (we maintain a patch program for WebIOPi upon a GitHub).

6. **Make Eyes.**

   Figure 3.17 shows an example of an eye implemented by a web camera. A lot of USB web cameras are cheaply available in the market and most of them come with a microphone, which can be used when we implement an ear for a robot later. The image captured by the web camera can be streamed into a web browser. MJPG-streamer is the open-source software that enables the video-streaming scenario.

7. **Make a Mouth.**

   Raspberry Pi has an audio jack interface (Figure 3.13). Therefore, we can use an active speaker (an active speaker is a speaker that has a built-in amplifier) as a mouth for the robot. For the input interface for speaking words, the browser's input field can be used. The words typed in the input field are sent to the voice synthesis software to read back the words as an audible human voice. We used open-source software, Open-Jtalk, and the communication between the browser and Open-Jtalk is implemented using a WebIOPi's extension functionality.

8. **Make an Ear.**

   Hardware wise, we can implement an ear using web camera's built-in microphone. Software wise, we will implement it by voice recognition software. Voice recognition by machine is one of the important research areas that both the industry and academia have been studying for many years.

Several voice recognition software packages are available for free for the use of academic purposes. We used open-source software, Julius. Since Julius is a program that continuously listens to the sounds collected by a microphone and output the result of the voice recognition, there needs to be another program that receives the outputs from Julius. We implemented such a program by Python fairly easily by modifying a simple program, which we found on the Internet. After the ear is implemented, we used this functionality to control a robot by voice (i.e. a voice remote controller).

3.3.4 Discussion

We'd like to discuss the use of this educational system for CPS to the different class of learners. This educational system was deployed to the two extreme age groups; one end is the elementary school student, and the other end is the graduate school student who never built such a system before but wished to learn how the CPS works.

Since the elementary school students and the university graduate students belong to completely different classes in terms of knowledge and skill, they clearly had different goals and objectives for learning CPS for the first time (Table 3.8).

Table 3.8

Different Goals and Objectives for the Different Class of Learners

	Elementary School Students	**Graduate School Students**
Goals	Create a visually unique robot that moves and can be controlled remotely.	Understand how the CPS components are connected and work together.
Objectives	Use of Tools, Switch Circuit, Programming	Programming, Network, Control Devices
Outcomes	Visually unique body, Web-Based Control	Control Logics, Network Configuration, Multiple ways of controlling CPS components

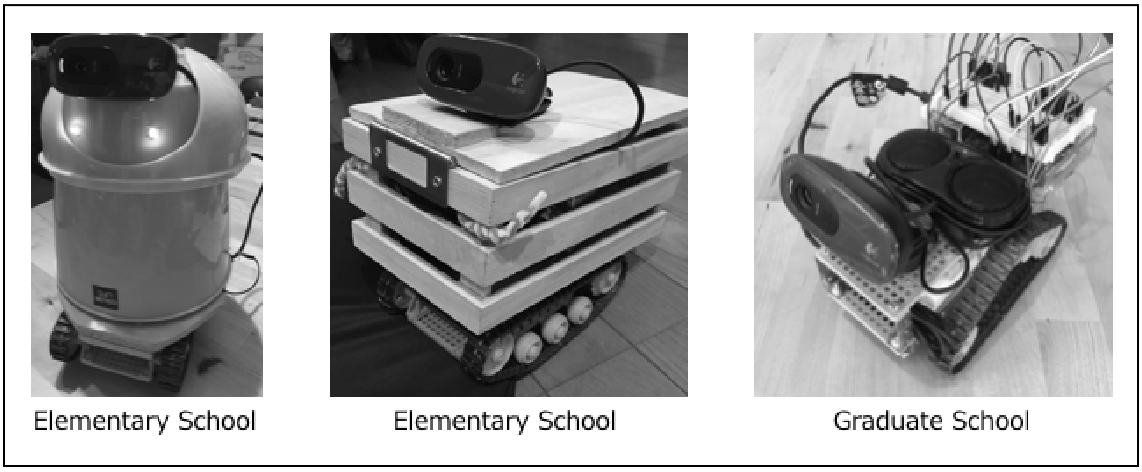

Figure 3.18. Different Bodies but shares the Same Architecture

For the elementary school students their goal was to create a unique movable robot, which they can control remotely. For the graduate school students their goal was to understand how the CPS components are connected and work together. The assumption was that such differences could be absorbed by the educational system that complies with Open-Closed-Principal (OCP), because such a system is flexible and adaptable to meet individual learners' needs.

Figure 3.18 shows actual outcomes. Obviously, the elementary school students learned how to use the tools to build the body of their robot with their own idea. And, some students added the LED eyes to their robot, which were not originally included in the educational system for CPS. This means that they extend the behaviour of the educational system to meet their own needs.

As to the graduate students, they had only one day and their goal was not to make their robot visually unique but to see how the CPS components are connected and work together. While they stayed simple with the body of the robot, they worked on programming the control code for motors, and tried the use of the external batteries to drive motors. Some of them even tried to control their robot with the voice recognition open-source software.

Here, we observed very different outcomes even though we used the same educational system. Yet, we did not have to make any modification to the educational system (i.e. closed-for-modification), but found it flexible enough to allow each learner to implement his or her own ideas (i.e. open-for-extension). This is the extremely powerful and effective feature of this educational system.

3.4 Building Online Learning Materials for Technical People

Machine Learning and Deep Learning are a particularly interesting category in the field of artificial intelligence in its third boom. We developed an online Machine Learning course between March 2016 and March 2017 to start human resource development in this field and it has been provided since April 2017. A Deep Learning course was also developed independently as an extension course of the Machine Learning course and has been provided since April 2018.

The goal of these two courses is not only to teach the theory of Machine Learning and Deep Learning but also to increase the number of practical technical professionals who can implement its technology. Therefore, practical engineering exercises cannot be omitted from the courses. However, it is not easy to properly assess and guide the growth of learners because each learner normally has a different level of knowledge and experience, which results in different learning outcomes when learning AI theory and when performing exercises on its realistic implementation (Felder and Brent, 2005). For that reason, advanced IT courses with such characteristics often take place in the form of a combination of face-to-face training and online learning (i.e., blended learning).

The online Machine Learning course and Deep Learning course that we developed were designed for learners with the same or similar intellectual level as a first-year university student. The goal of these two courses is to increase the number of engineers who not only understand AI theory but also can practically implement it. The course syllabus was created with reference to several leading AI massive open online courses

(“Machine Learning | ML (Machine Learning) at Georgia Tech,” n.d.) (“Machine Learning Engineer | Udacity,” n.d.). Main subjects covered in the syllabus were selected from the perspective of fostering AI engineers capable of dealing with unknown problems in the future. Also, different types of solutions on the same problem are explained for the learners to be capable of selecting an appropriate solution under constraints they are given in the future.

3.4.1 Proposal Method

- Theoretical Basis for the Course Design

In order to evaluate the quality of the online course design and the learner's proficiency, a theoretical framework used to measure the learners’ performance was required. The learning theories that can be used as a theoretical framework have been studied for a long time. We adopted the argument of Ertmer and Newby (Ertmer and Newby, 1993) as the theoretical basis for our course design, which is described below.

Ertmer and Newby (Ertmer and Newby, 1993) argued their learning theory from the three perspectives of behaviorism, cognitivism, and constructivism, and discussed in detail the philosophical differences of these perspectives and the differences of teaching methods which arose from such philosophical differences. They suggested that learning theory serves as a basis to verify the correctness of pedagogical learning strategies and also as a basis for selecting specific strategies. These learning theories differ in terms of "how to define learning," and such difference yields different learning goals, teaching methods, and evaluation of learning outcomes.

Behaviorism focuses only on observable learner behavior changes. The changes that occur in the unobservable mind are considered to be ultimately manifested in behavior, and therefore only visible behavior is considered for evaluation. In other words, the definition of learning in this view is "the change of behavior (the ability to reflect acquired knowledge in behavior)."

Cognitivism focuses on cognition as a premise of behavior and posits that behavior changes when the way of cognition changes. The definition of learning from this point of view is "the change in cognitive structure (the ability to extract a pattern and use acquired knowledge)." Although there is a difference, behaviorism and cognitivism are the same in that the world is regarded as an object that can be learned about as an objective existence separate from the learner.

Constructivism does not treat the learner and the world as separate entities, and the world is understood as something that is given meaning and configured by the learner itself. The definition of learning from this perspective is "finding the meaning by yourself (being able to create and use knowledge by yourself)."

Since learning is a complicated and time-consuming process and strongly influenced by the individual's experience and knowledge, Ertmer and Newby (Ertmer and Newby, 1993) insist that appropriate learning strategies will change according to the learner's proficiency and learning goals. According to this view, in selecting a learning strategy, it is necessary to sufficiently consider both the learner's knowledge level and the cognitive processing level, which are required to handle the target learning task. Figure 1 (Ertmer and Newby, 1993) shows which learning theory-based learning strategy is appropriate for the learner, based on these two levels.

Figure 3.19 shows that learning strategies based on different learning theories overlap. However, it turns out that it is difficult to switch from behaviorism strategies to cognitivism strategies if the level of the learner’s task knowledge with behaviorism strategies does not increase. Similarly, it has been shown that it is difficult to switch from cognitivism strategies to constructivism strategies if the level of the learner’s task knowledge with cognitivism strategies does not increase.

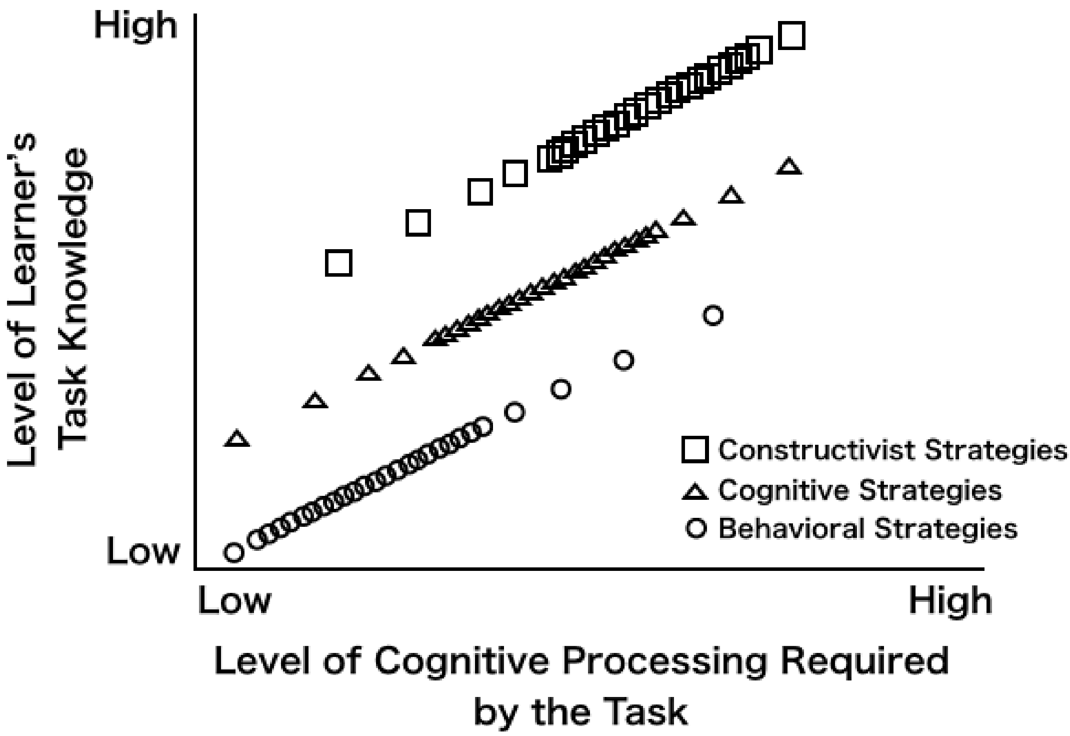

Figure 3.19. Comparison of the associated instructional strategies of the behavioral, cognitive, and constructivist viewpoints based on the learner's level of task knowledge and the level of cognitive processing required by the task (Ertmer and Newby, 1993, p.69).

■ Implementation of the Learning Theory and Course Architecture

In aligning the goals of the two courses with the learning strategies, it is better to use behaviorism strategies when learners are trying to accumulate knowledge about AI theory because learners' knowledge is too low to use cognitive strategies. At the stage of learning about how to implement the theory as working programming code, it is necessary to demonstrate that the acquired knowledge can be used effectively in practice, so a cognitivism learning strategy is appropriate.

Design methods for online courses have been studied in the field of instructional design and various instructional design models have been proposed.

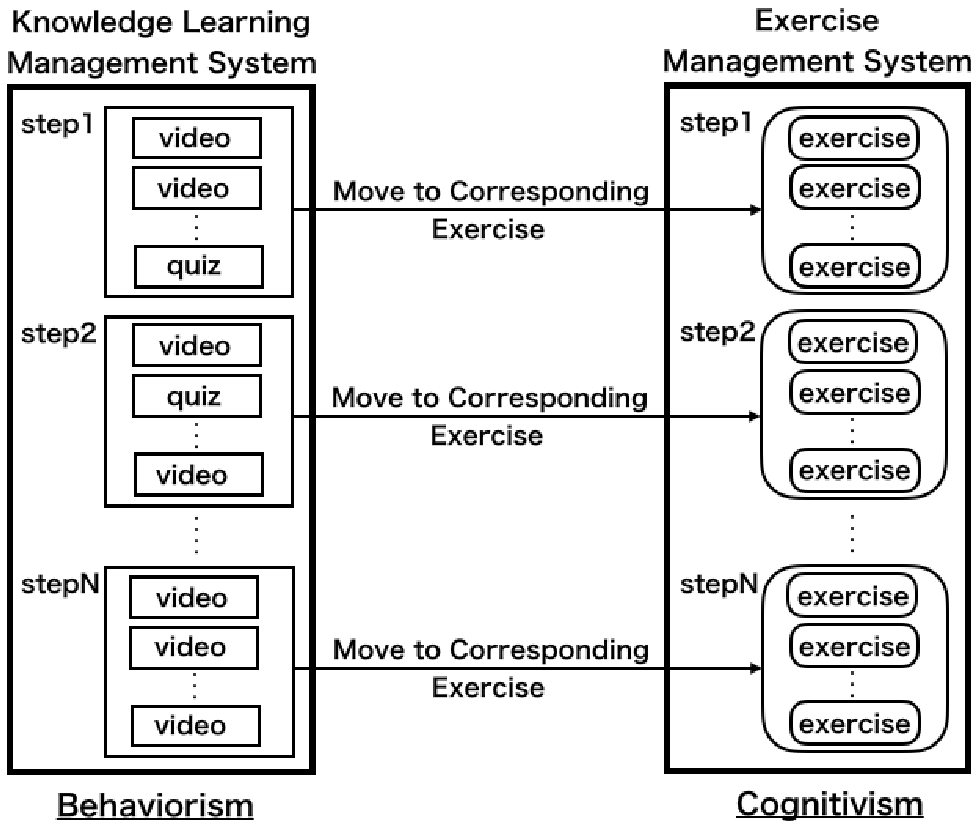

Figure 3.20. Hybrid course architecture.

We propose a hybrid course architecture that combines behaviorism and cognitivism strategies (Figure 3.20) because the goals of the two courses do not require constructivist learning strategies. Here, the system built based on the behaviorism approach (Figure 3.20, left) is a system with the goal of acquiring knowledge, while the system built based on the cognitivism approach (Figure 3.20, right) is a system that allows learners to learn how to implement the knowledge through exercises. For the reasons above, we will call the behaviorism-based system 'the knowledge learning management system' and the cognitivism-based system 'the exercise management system' respectively.

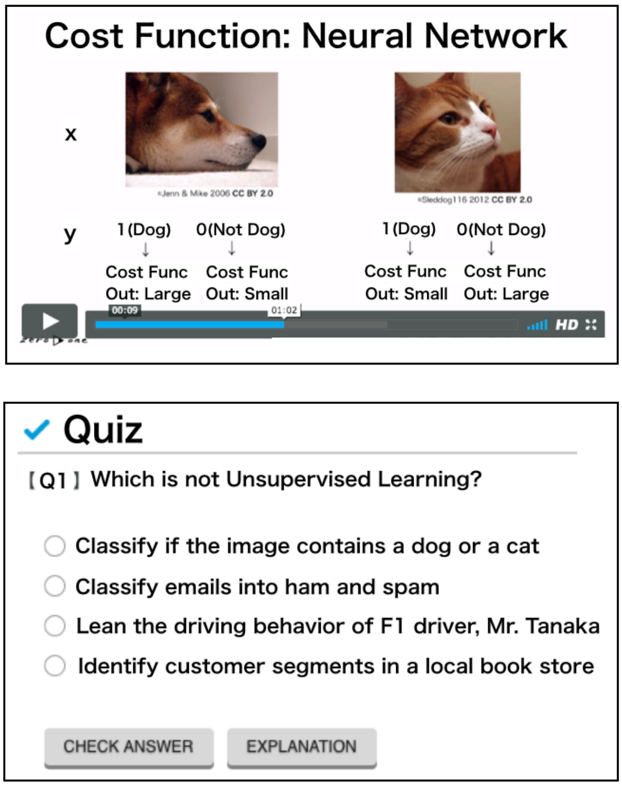

Figure 3.21. Example: Short video (top) and quiz (bottom)

Behaviorism learning strategies can be implemented using a conventional learning management system (LMS) that can handle lecture-style teaching methods using videos and texts (Figure 3.21, upper). The learning outcomes can be objectively evaluated by testing the knowledge learned through the learning tasks, i.e. quizzes, placed in the learning units using the choice problem format (Figure 3.21, bottom).

In order to implement a cognitivism-based learning strategy, a traditional learning management system (LMS) cannot be used because it must provide the learners with an environment where programming code can be executed. Therefore, we prepared such a learning environment with Jupyter Notebook, which is an open source computational notebook ("Project Jupyter," n.d.). A computational notebook is an application like Microsoft Word, which can manage a text document as a file, but it can also execute programming code written in the document.

Although notebooks of this type have gained popularity in commercial math systems such as Mathematica (“Wolfram Mathematica,” n.d.) and Maple (“Maplesoft - Software for Mathematics, Online Learning, Engineering,” n.d.), Jupyter Notebook is open source, actively developed and supported. Many types of computer language are supported too. By using Jupyter Notebook, learners can write their own program and visually confirm the execution results in real time (Figure 3.22). In addition, we implemented an automatic scoring feature for the exercises in order to give the learners immediate feedback for what they did with them, and the executions of the exercises were recorded in a log file in detail. Moreover, we provided the results of the exercises visually so that the learners could monitor progress by themselves.

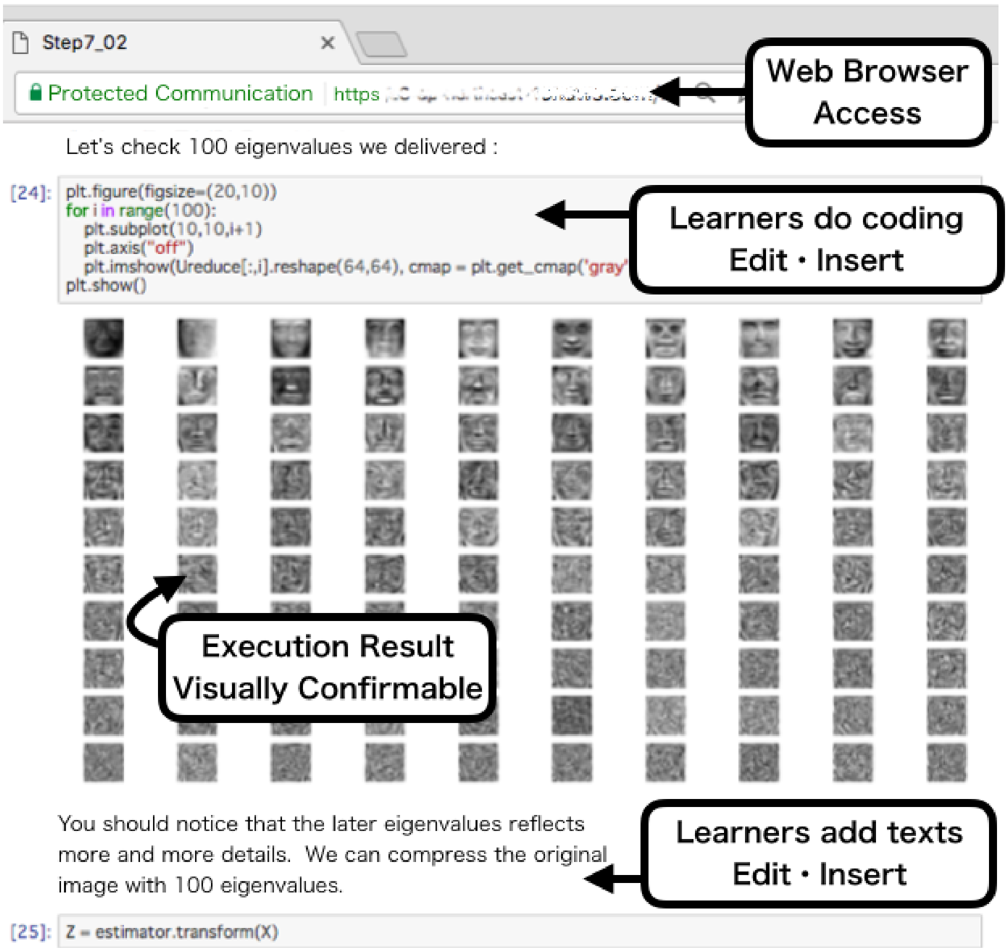

Figure 3.22. Exercise environment implemented with Jupyter Notebook.

3.4.2 Evaluation Method

Figure 3.19 suggests that efficient learning strategies differ depending on the level of learners' task knowledge (Ertmer and Newby, 1993). Therefore, it is important to understand the level of learners' task knowledge to provide an appropriate learning strategy for each learner. Figure 3.19 also suggests that learners found below the line of behaviorism learning strategies cannot work on a given task by themselves, so they won't appear in this area. Therefore, the distribution of the learners should appear to the upper right of this line. In fact, we observed the same pattern with the distribution of the learners in both the Machine Learning course and the Deep Learning course.

■ Evaluation of Implemented Learning Theory

If the implementation of learning theory is properly done, we should be able to obtain a Figure 1-like diagram with two types of collected data from the implemented system which represent the level of learners' task knowledge and level of cognitive processing required by the task. For example, we can create a diagram with the results of the pretest for the knowledge on the vertical axis and the number of trials each learner made over all the exercises at the end of the course on the horizontal axis; it will be like Figure 3.23. On the horizontal axis in Figure 3.23 the cognitive processing level is lower on the right side of the figure because it is considered that the cognitive processing level is lower as the number of trials increases.

The minimum number of trials is equal to the total number of challenges a learner performed on all the exercises. Therefore, the minimum number of trials is equal to the number of prepared exercises. For example, if 70 exercises are prepared for the course, learners have to go through at least 70 exercises, which makes the minimum number of trials 70.

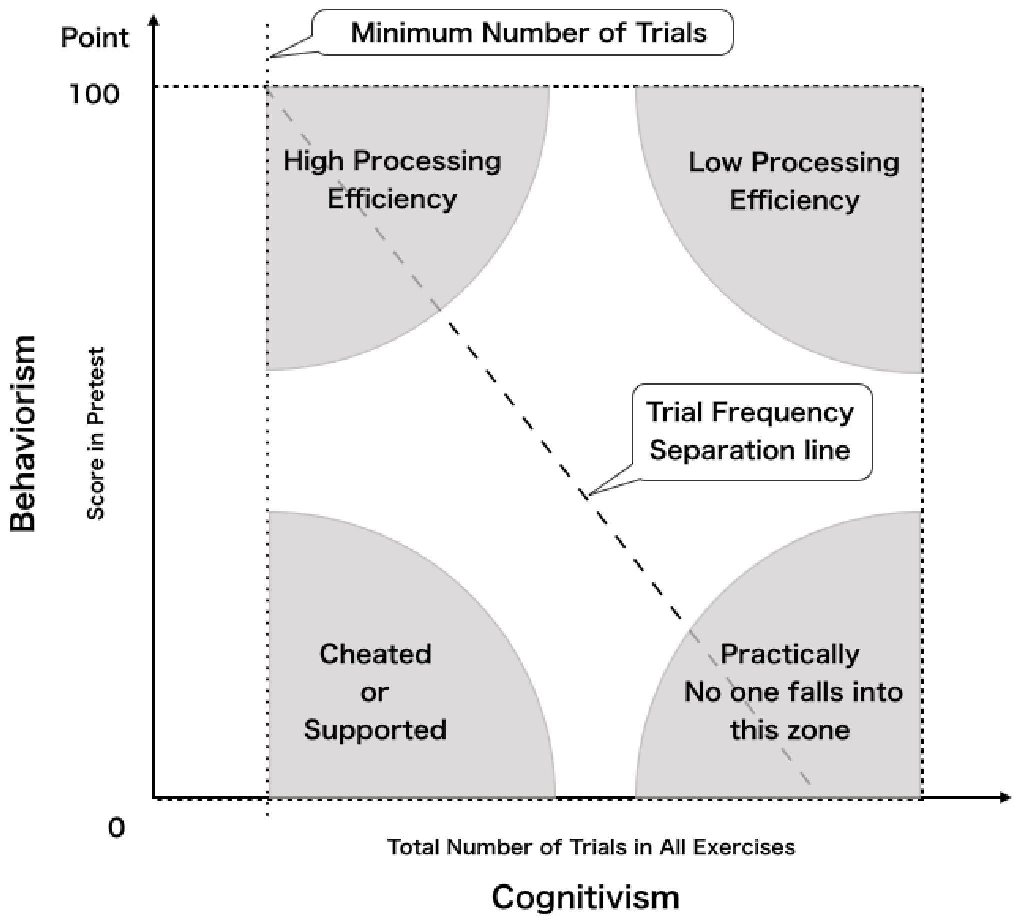

Figure 3.23. Trial frequency separation line.

If the students are found to be in the lower left area in Figure 3.23, it means their pretest score was extremely low and the number of trials they made on the exercises was extremely small. It is natural that learners with extremely low pretest scores are unlikely to clear exercises in a single attempt. Therefore, it is highly possible that they could have cheated or could have been assisted by a person who knew the correct answers. On the other hand, if students are found to be in the upper left area in Figure 3.23, it means their pretest score was very high and they cleared the exercises in only a few attempts. They are high performers in processing tasks. The students found in the upper right area in Figure 3.23 got high scores on the pretests, but they are learners who do not have strong ability to handle given tasks because they needed to try the given exercises many times to clear them.

It is our assumption that we should be able to find a line like the trial frequency separation line described in Figure 3.23 and the learner distribution should appear in the upper right of this line. The reason is that Figure 3.23 corresponds to the gray part of Figure 3.24 which is drawn by reversing the left and right of the horizontal axis of Figure 3.19.

The upper part of the gray area in Figure 3.24 is aligned with a 100-point line of the pretest for knowledge assessment. The trial frequency separation line is aligned with the line that represents the behaviorism learning strategies (the line where the circles in Figure 3.24 are lined up).

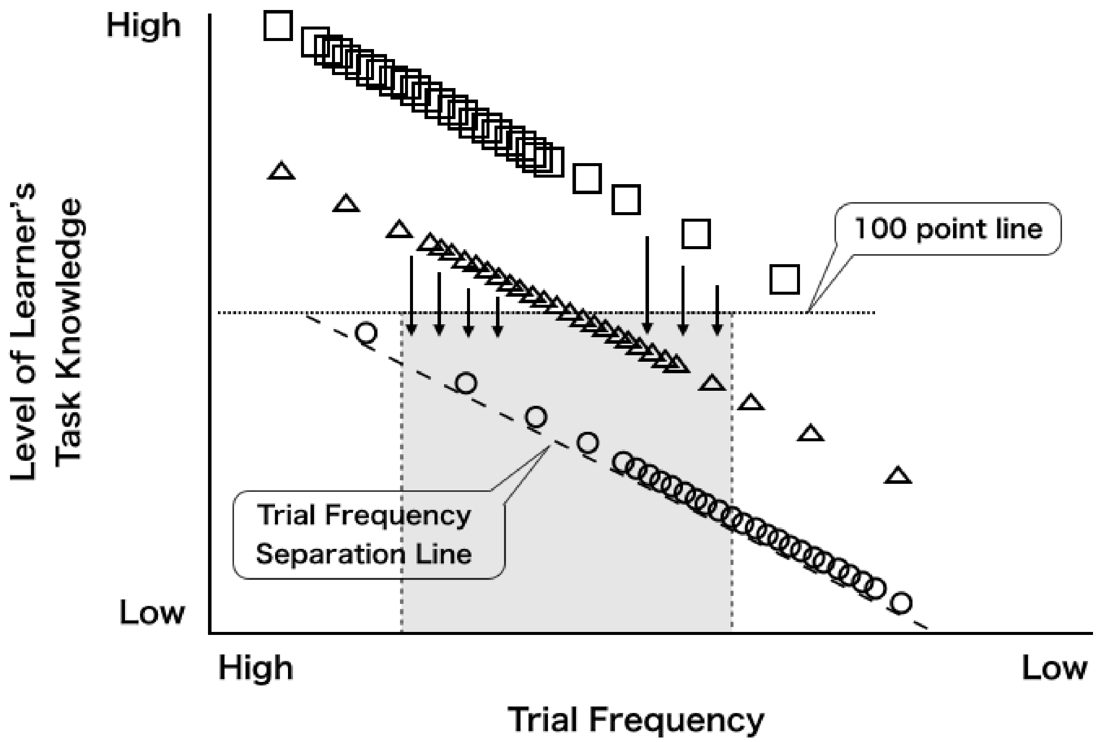

Figure 3.24. Trial frequency separation line in relation to Ertmer and Newby's Theory Line.

Also, the number of trials learners made to go through all the exercises is at least the number of given exercises, and it is not impossible to try the exercises as many times as learners want because the duration of the course is limited. Therefore, the processing level on the horizontal axis moves within a limited range. The gray area in Figure3.24 is enclosed by this limited range on the horizontal axis and the range of knowledge levels is from 0 to 100 points on the vertical axis. Since the learners who have knowledge beyond the knowledge tested on the pretest exist above the 100 point line in Figure 3.24, such learners appear in the gray area (pointed at by the solid down arrows).

If a learner already knows answers for some reason, she or he will appear as a high performer in Figure 3.23. We cannot check whether they are cheating or not with this diagram alone. If checking for cheating is needed, it could be captured by monitoring other data collected by the system. For example, there is a tendency that the time between exercises is extremely short or the number of mistakes is unnaturally few when such cheating occurs.

3.4.3 Evaluation Result

- The relationship between the pretest score and the number of trials

When we designed the pretest for the knowledge assessment, the first problem was that we did not know what kind of questions should be asked to yield meaningful results which reflect the level of learners' knowledge.

Since there was no sample pretest available, we decided to ask questions on basic mathematical knowledge and programming knowledge which frequently appear in our courses. The difficulty level of each question was set for the learners to be able to find the answer within a minute if they were already familiar with the question asked. Figure 3.25 shows some sample questions.

$$A = \begin{pmatrix} 1 & 2 \\ 3 & 0 \end{pmatrix} \quad B = \begin{pmatrix} 0 & 1 \\ 2 & 0 \end{pmatrix}$$

Calculate AB and answer the value (trace) that added the diagonal.

- ○ 1
- ○ 2
- ○ 7
- ○ 8
- ○ I don't know

Answer what's in c after the execution of the following code:

```
a = [3, 2, 0, 5]
c = a[1] + a[3]
print(c)
```

- ○ 3
- ○ 4
- ○ 7
- ○ 8
- ○ I don't know

Figure 3.25. Examples of pretest questions for mathematics and programming.

Figures 3.26 and 3.27 show the number of trials made by learners on all the exercises on the horizontal axis and the score of a pretest on the vertical axis, on the Machine Learning course and Deep Learning course, respectively. On the Machine Learning course, there are 76 programming exercises in total. Therefore, a learner has to try to work on exercises at least 76 times. In other words, 76 is the minimum number of trials. Similarly, the minimum number of trials for the Deep Learning course is 77.

In Figures 3.26 and 3.27 we can observe a similar line (dashed line in each figure), which corresponds to a trial number separation line. The fact that such a similar line is observed from the two different courses supports the idea that a pattern exists between the pretest score and the number of trials that the learners need to finish an exercise, as was suggested by Ertmer and Newby.

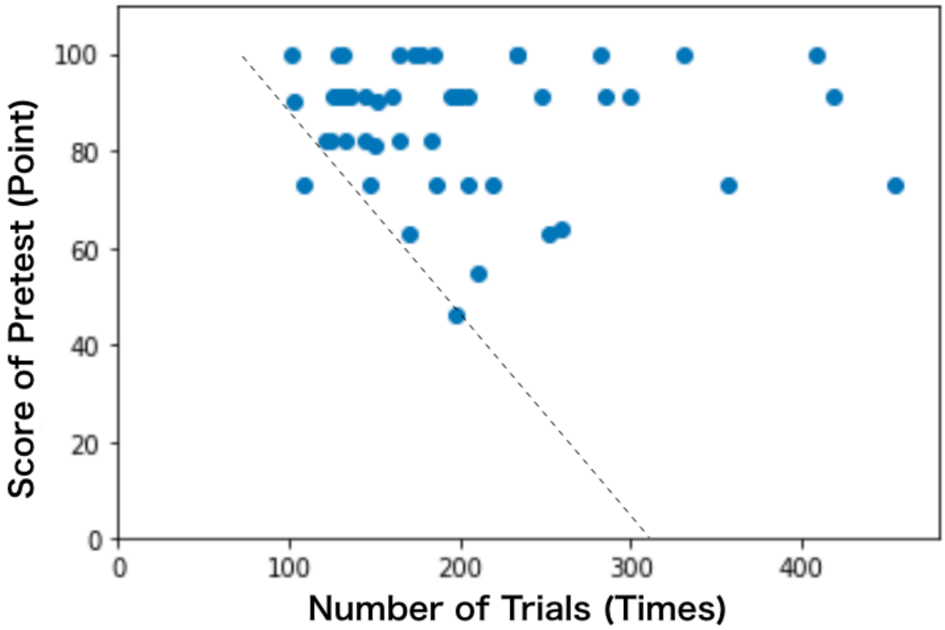

Figure 3.26. Trial frequency separation line for the Machine Learning course

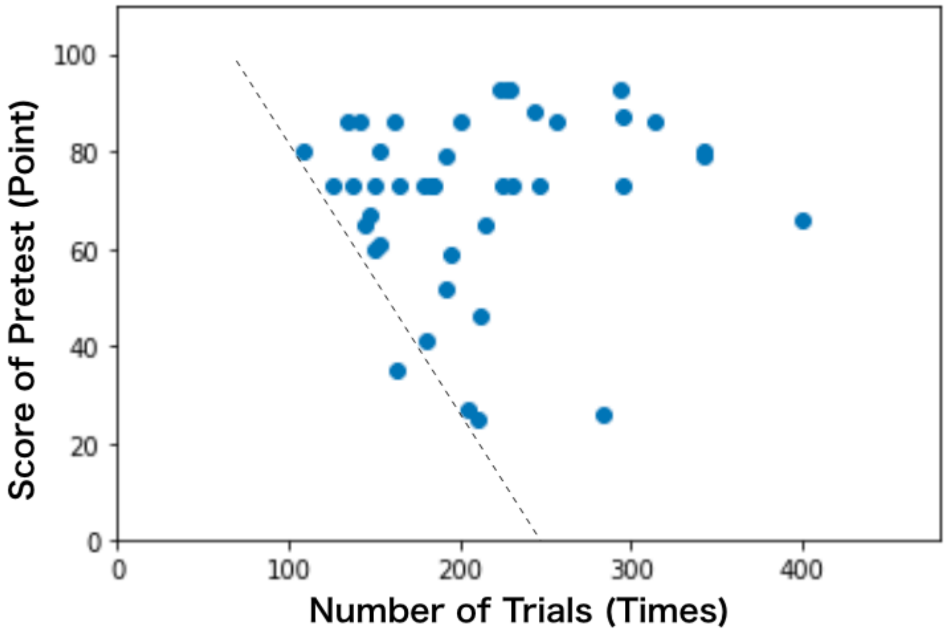

Figure 3.27. Trial frequency separation line for the Deep Learning course.

■ Possibilities of Self-Achievement in Online Learning

A personal support channel was provided by email for the learners who could not work on the exercises by themselves. We counted the number of personal support requests by each learner. Support inquiries not related to the exercises were also received via this support channel, but we did not include them in the count of the number of personal support requests. As a result, the distribution of learners who needed support for the exercises became clear as each of them appeared as a colored square mark in Figures 3.28 and 3.29 for the Machine Learning course and the Deep Learning course, respectively. The size of a square reflects the number of questions made by the corresponding learner.

In both courses, it is clear that the number of questions from high scorers (above 90 on the pretest) was zero. In other words, all the high scorers on the pretest finished the course by themselves without any support.

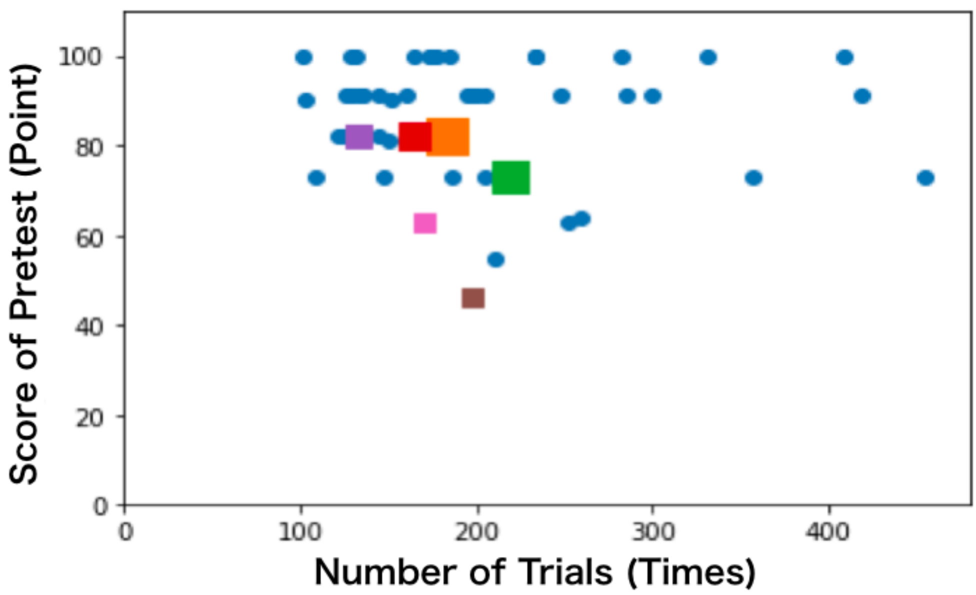

Figure 3.28. Number of exercises and actual support requests needed in the Machine Learning course.

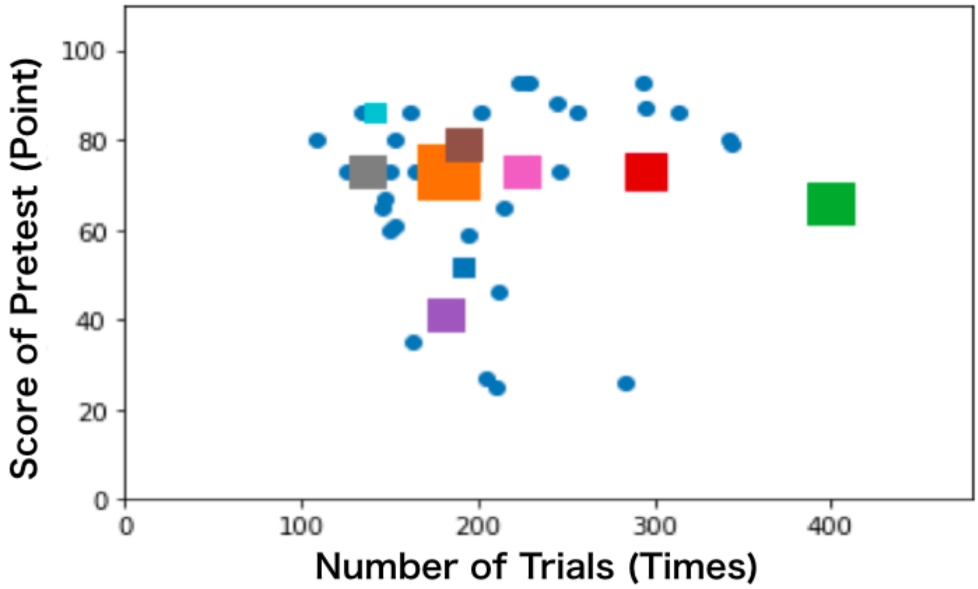

Figure 3.29. Number of exercises and actual support requests needed in the Deep Learning course.

On the other hand, learners who did not get high scores on the pretest, which was designed to check the basic knowledge of mathematics and programming skill, found themselves in trouble completing the exercises on their own. In fact, there is a sudden increase in the number of questions from the learners whose pretest scores were lower than 80. We observe this tendency in the pretest score range between 60 and 80 in Figures 3.27 and 3.29. Learners in this score range might have reached a marginal level of knowledge to work on the exercises with some personal support.

Many learners want to know, before course entry, whether they have a sufficient level of knowledge to complete the courses on their own. During course development, we could not predict what kind of pretest would be useful to predict if learners were ready to take the courses. The data gathered through the course offerings suggest a pretest that measures learner's basic mathematics knowledge and programming skill seems to be a good way to predict whether learners can finish the course by themselves.

■ Effectiveness of the Presence of Study Peers

Several learners finished the course without any personal support even though their pretest scores were low. The reason for this phenomenon became clear through the interviews with the learners who took these courses; such learners took courses in groups of two or more people and had opportunities to have some personal support from their peers. Groups of more than two people who did not use the support channel always included high scorers on the pretest.

In the Machine Learning course, we found that a single learner, who took the course alone, needed about 18 times more support than a group learner, who took the course in a group (Figure 3.30). The same pattern was observed in the Deep Learning course. However, this difference is more prominent in the Deep Learning course than in the Machine Learning course as a single learner needed about 26 times more support than a group learner (see Figure 3.31).

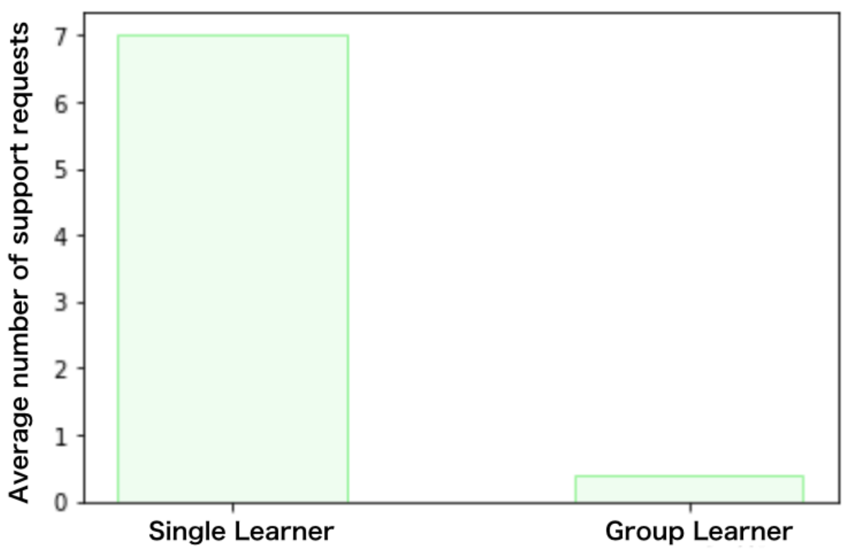

Figure 3.30. Average number of support requests in the Machine Learning course.

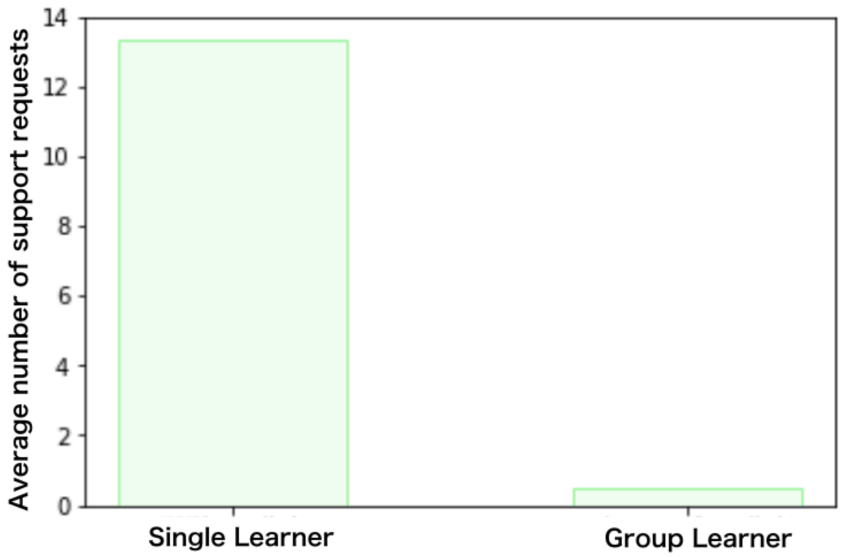

Figure 3.31. Average number of support requests in the Deep Learning course

These results indicate that low scorers on the pretest need a personal support environment. For example, it might be effective to use an online forum where peers can help each other.

■ Time Interval Between Exercises

High scorers on the pretest had a tendency to challenge exercises more than low scorers. We initially thought the time spent on one exercise would be shorter with high scorers than with low scorers. If this assumption is true, high scorers would finish the exercises sooner than low scorers. Since the time spent on one exercise could not be measured directly, the average time intervals between two adjacent exercises were investigated, and we found the difference of the time intervals was less than a minute among learners regardless of their scores on the pretest in the Machine Learning course (Figures 3.32) and was also less than a minute among learners whose pretest scores were between 40 to 100 in the Deep Learning course (Figure 3.33). It seems odd to find the low pretest scorers (between 20 and 40) have shorter intervals than high scorers (Figure 3.33).

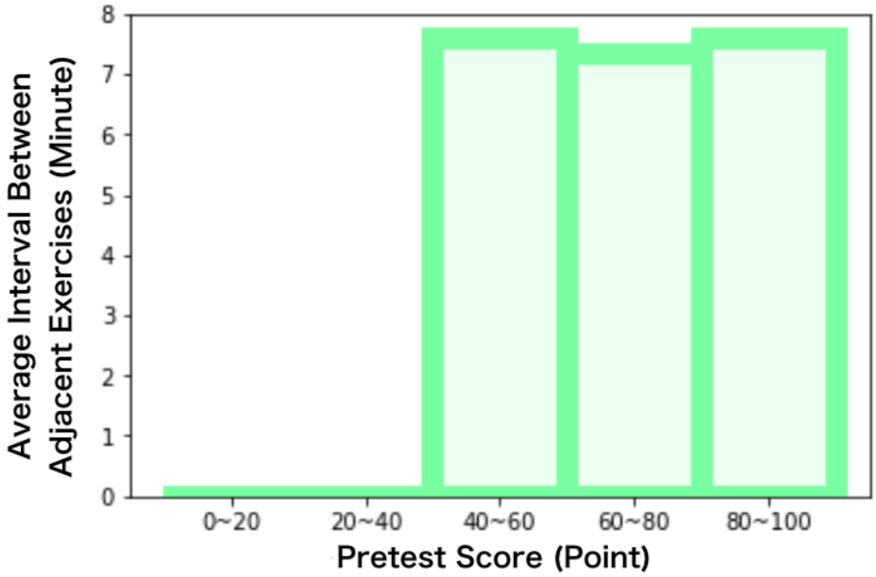

Figure 3.32. Average interval between adjacent exercises in the Machine Learning course.

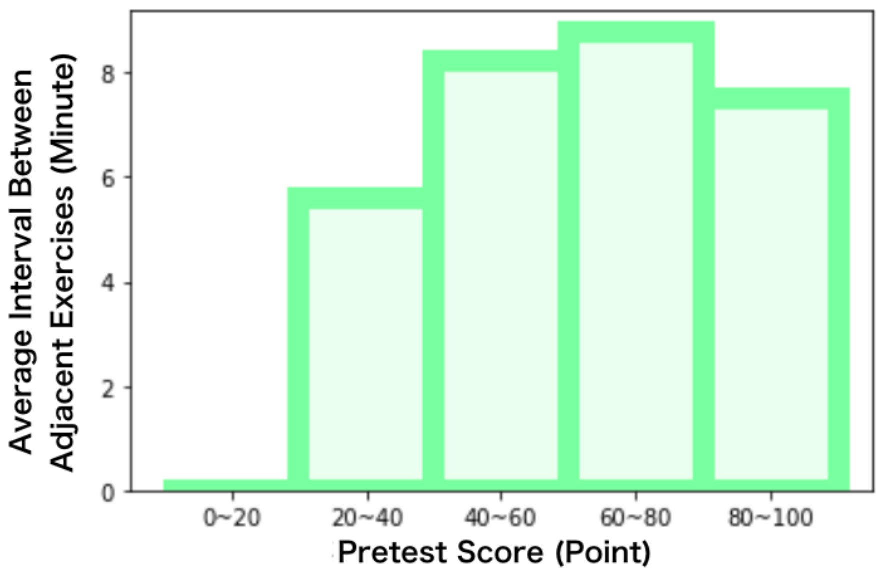

Figure 3.33. Average interval between adjacent exercises in the Deep Learning course.

However, this aligns with the fact that they were supported by the learning peers or the support channel to find the answers for difficult exercises without struggling to find the solutions by themselves.

When using a computational notebook like Jupyter Notebook as an exercise environment, the finding that the interval between two adjacent exercises is almost constant regardless of the level of the learners suggests that it is difficult for the learners to shorten their time spent on the exercises. However, it also suggests that the minimum time needed to finish all the exercises can be estimated with quite a high accuracy.

■ IMPROVING COURSES

We cannot rule out possible problems originating from teaching methods and learning materials as the reason why learners cannot proceed with their learning effectively. Improving the courses in terms of teaching methods and learning materials helps to lower the support costs not only for the learners but also for the course providers.

● Identifying the Exercises to be Improved

The exercises which need to be improved first are the ones that many learners actually needed help with through a support channel. However, even though the learners did not need much support, it might be necessary to review the exercises if many learners required many attempts to complete them.

Figure 3.34 is a scatter diagram of the Machine Learning course, with the horizontal axis representing the number of actual support requests, the vertical axis representing the number of trials on each exercise, and the size of a circle representing the variance of the number of trials on each exercise. The exercises which should be reviewed for improvement first are the ones with a large number of actual support requests and a large number of trials. Therefore, the exercises that are located in the upper right area in Figure 3.34 should be improved first. Normally it is difficult to improve all the exercises because it would cost too much. For that reason, it is helpful to determine an improvement control limit line, shown as a dotted line in Figure 3.34, and try to improve the exercises which appear to the upper right of the line. However, in practice, not all online courses can provide a support channel because it costs too much, so it is not always possible to create scatter plots like Figures 3.34 and 3.35. Therefore, it is useful if we can identify which exercises need to be improved without drawing an improvement control limit line.

The exercises mapped to the upper right area of the improvement control limit line as shown in Figure 3.34 have a large variance in the number of trials (i.e., the size of a circle is large). The same pattern is found for the Deep Learning course, as shown in Figure 3.35. These results suggest that the exercises which need to be improved can be identified simply by checking if the variance of the number of trials on each exercise exceeds predetermined criteria.

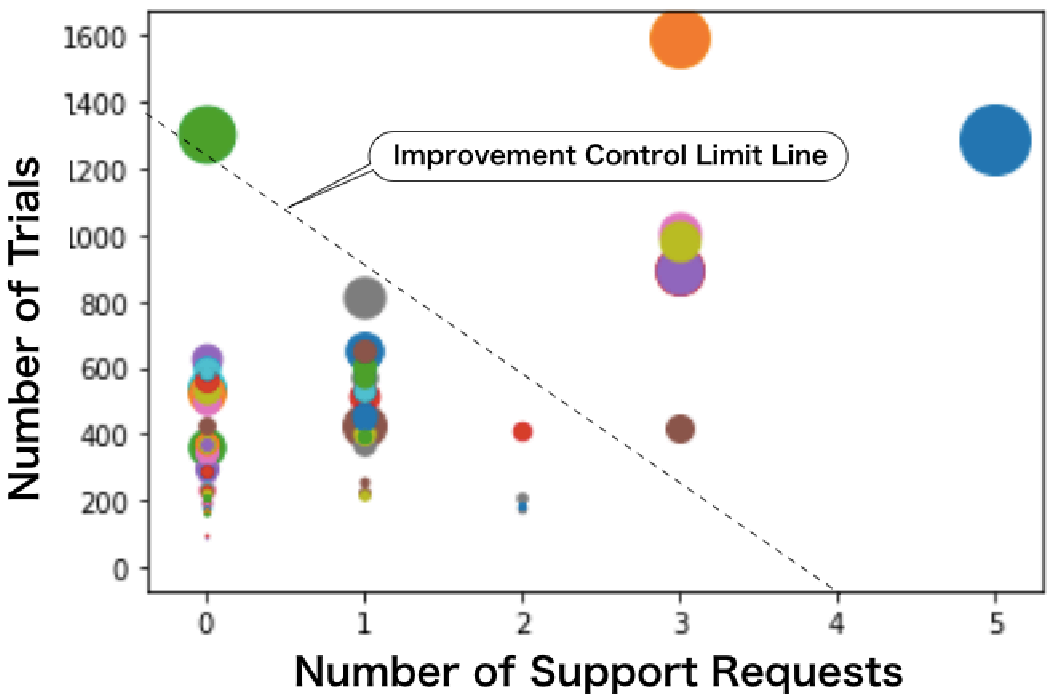

Figure 3.34. Improvement control limit line for the Machine Learning course.

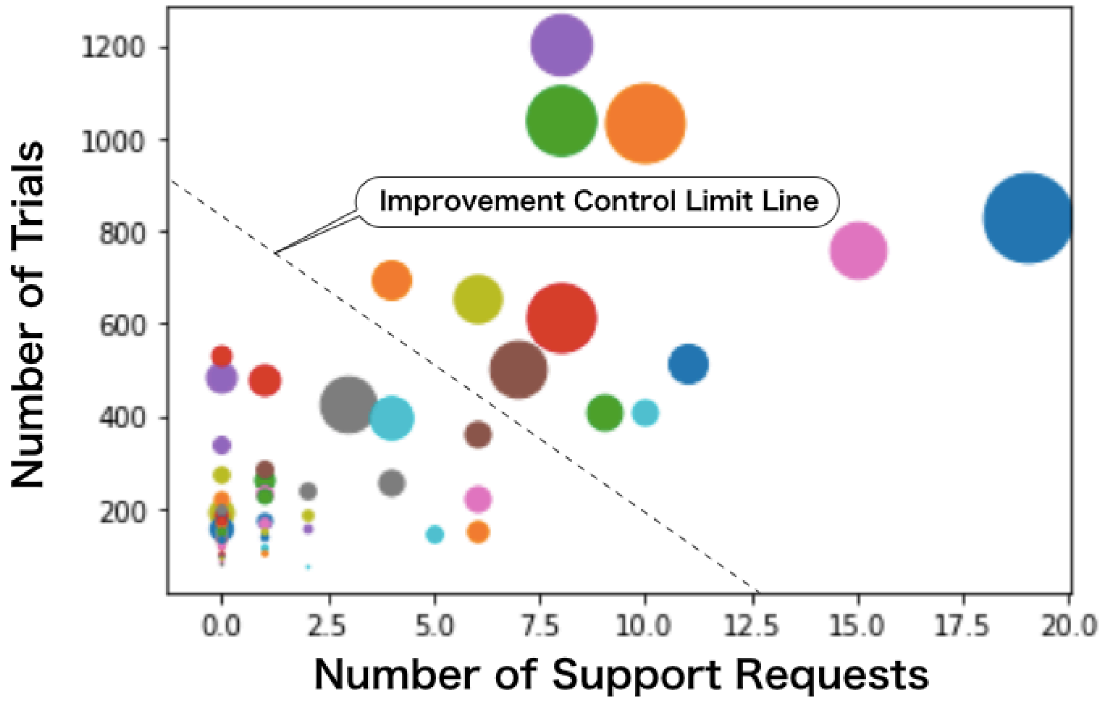

Figure 3.35. Improvement control limit line for the Deep Learning course.

- **Improving the Teaching Method**

Since the learning data are collected on the premise of a specific teaching method that the learning platform adopted, in principle it is impossible to identify areas for improvement in the teaching method from the data. Therefore, we investigated areas for improvement of the teaching method through feedback from the learners who took our courses. The feedback indicated that many experienced a gap when transitioning from the behaviorism learning approach to the cognitivism learning approach.

In order to address this problem, we modified the teaching method so that learners could practice basic versions of the practical programming exercises. The basic versions only provided the essence of the exercises on the LMS, which plays the role of the knowledge learning management system in our system (Figure 3.36).

Figure 3.36. Programming window implemented on the LMS.

By introducing such a programming exercise environment on the knowledge management system side, we found, through the interview after the completion of the courses, about 39% of learners enjoyed this feature.

Common open source learning management system (LMS) packages such as Moodle ("Moodle - Open-source learning platform | Moodle.org," n.d.), which have been adapted in many higher educational institutions, do not provide a programming environment as default. Therefore, a special implementation must be carried out to provide a programming environment (Rodríguez-del-Pino et al., 2012). It would trigger the expansion of advanced technology online courses if popular LMS packages were to support such a programming environment by default in the future.

3.4.4 Discussion

The purpose of this research was to identify the issues faced by learners in completing fully automated online courses on Machine Learning and Deep Learning on their own with a good understanding of both AI theory and its implementation. Five issues were found:

First, basic mathematics knowledge and programming skill need to be checked to predict whether learners can finish online courses on their own. Second, low scorers in a basic pretest need to have some personal support. Third, it is difficult for learners to shorten their time spent on the exercises because the time spent between the exercises is almost the same among the learners regardless of their pretest score. Fourth, it is necessary to pay attention to the size of the variance of the number of trials on each exercise in order to judge which exercises need to be improved. Fifth, in order to make a smooth transition between AI knowledge and practical exercises, basic versions of the practical programming exercises in advance helps learners.

The gap between AI knowledge and practical exercises corresponds to the gap between the abstraction and its implementation. Much research has tried to address this gap. Kobayashi et al. discussed this gap in the context of the gap among vision, strategy, business process, and IT system and tried to solve this issue by the assurance case method, while we did not investigate the gap in this context (Kobayashi et al., 2018a). Seya and Shirasaka (Seya and Shirasaka, 2016) tried to minimize the gap related to the learner's knowledge and experience level by utilizing the Open-Closed Principle (Meyer, 1988). Future research needs to identify the differences between existing teaching methods in order to utilize each approach appropriately and effectively.

It is difficult to supply the large number of technology-ready people needed by the emerging technology sector like AI only by direct teaching methods in classes typically conducted in the educational fields such as universities and graduate schools. In order to supply tens of thousands of leading-edge technical professionals required by the emerging technology sector, future research on the five issues identified by this research needs to be carried out, because online education is one of the promising methods to solve this problem.

Besides, as digital technology becomes increasingly influential, it is important to find an effective teaching method not only for technical people but also for non-technical people (Seya et al., 2019a). Future research needs to reveal how different teaching methods and approaches can solve unique issues for different types of learner trying to understand Machine Learning and Deep Learning.

3.5 Story-building Method Suited for Non-Technical Adults

In order to make complex technology like AI easy to understand, it is necessary to loosen the thread of complicated intertwined stories and linearize the stories. Moreover, if the elements that make up the story are connected to each other by some clear reason, it becomes easier for learners to find a reason to learn each element in relation to the others. So, we looked at history as a way of linearizing stories because history is essentially linear in the sense that things occur chronologically. Moreover, there are many cases in which two events are connected by a cause-and-effect relationship. This is good for learners as it means the reasons why they need to understand the topics are naturally understood.

3.5.1 Proposed Method

■ Procedure to create a story-based lecture

As a method of constructing lectures based on historical stories, we propose the procedure shown in Table 3.9. Step 1 to Step 4 are abstract work to determine the major flow of the lecture, and Step 5 to Step 9 are implementation work to make concrete the lecture content.

It is difficult to predict what would happen in an actual lecture session with abstract work (i.e., Step 1 to Step 4) alone. Therefore, after the implementation work (i.e., Step 5 to Step 8), problematic parts will come to light. If such problems are found, iteration from Step 8 back to Step 2 is repeated.

Table 3.9

Procedure to Create a Story-based Lecture.

Step	Description
Step 1	Set a concrete learning goal.
Step 2	Identify chronologically related main topics which are necessary for accomplishing the concrete learning goal.
Step 3	Identify sub-topics which are necessary for accomplishing the goals of main topics.
Step 4	Temporarily fix main topics and sub-topics as lecture blocks.
Step 5	Implement main topics as chronologically ordered lecture blocks. Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block becomes too large.
Step 6	Implement lectures for large sub-topics as independent lecture blocks.
Step 7	Implement both core learning tasks for all learners and advanced learning tasks for advanced learners in each lecture block. Learning tasks should be broken down to small, related learning blocks to enable the agile method.
Step 8	Fix the lecture blocks if they are not compatible with administrative constraints. Go back to Step 2 if it is necessary to meet the constraints.
Step 9	Place an introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block. Place an outline session at the beginning of each lecture block to explain the role of the lecture block in relation to the previous topic.

When all the lecture blocks on the chronological storyline are completed in Step 8, a new lecture block that explains the flow of the whole lecture is created, and that block is placed as the first lecture block for the course in Step 9.

The following explains the points to be noted in the work of each step with reference to Table 3.5.1 and Figure 3.37.

- Step 1: Set the learning goal to produce as concrete a deliverable as possible. Setting the goal concretely makes it easy to select the learning topics needed to achieve that goal. This will help with the work from Step 2 onwards.

- Step 2: Choose the main topics needed to achieve the learning goal. However, the topics selected here are topics with time-series dependency. Arrange the lecture blocks to teach these topics in historical order. This process will clarify the boundaries between the main topics and other topics.
- Step 3: Identify the sub-topics needed to teach the main topics. Here, it is not necessary to be aware of the chronological dependencies of these sub-topics. Since these are topics determined in Step 2 which have no time dependency on the main topics, they are likely to be topics that are related to multiple topics, such as mathematics.
- Step 4: Temporarily fix the selected main topics and sub-topics, assuming that they will be taught as lecture blocks.
- Step 5: Since sub-topics do not depend on time, there can be multiple places where they can be inserted. The appropriate time to learn a sub-topic is right before learners actually use that knowledge. However, if a large sub-topic is inserted into the chronological storyline, learners would spend too much time on learning the sub-topic. This would promote the elimination of previously learned stories from the learner's memory. In order to get into the chronological storyline while avoiding such a problem, sub-topics should be broken down to smaller pieces.
- Step 6: Large sub-topics are implemented as lecture blocks that are taught independently.
- Step 7: Each lecture block should implement two types of learning task: core learning tasks and advanced learning tasks. These learning tasks are prepared for all learners and for advanced learners respectively.
- Step 8: If there is no problem in managing a lecture block, fix the contents of the lecture block. If problems occur, such as when a particular lecture block takes too long, adjustments will be required. A problematic lecture block might need to be divided into two lecture blocks. In that case, return to Step 2.

- Step 9: Create a new lecture block that explains the flow of the whole lecture, and place that block as the first lecture block on the chronological storyline. In addition, at the beginning of each lecture block, prepare a session to explain the position of the lecture block in the whole lecture.

■ LECTURE BLOCK

Each lecture block should have two types of flow: lecture flow and hands-on lab flow. Lecture sessions explain learning objectives and are placed on the lecture flow. Hands-on practice sessions are for the learners to do learning tasks using a computer and are placed on the hands-on lab flow. Each session should be implemented in a relatively short time (5 ~ 15 minutes). A hands-on practice session should follow right after the corresponding lecture session is completed. It is recommended to configure two adjacent sessions to have a causal relationship between them. Figure 3.38 shows the two types of flow and the sessions on each flow.

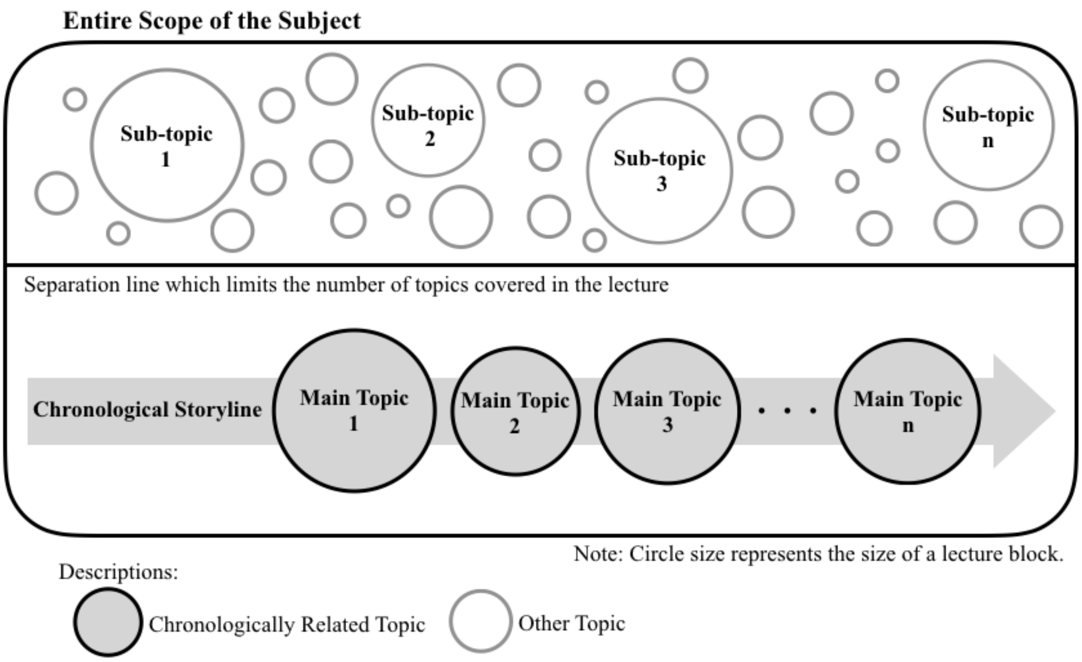

Figure 3.37. Configuration of Different Learning Topics.

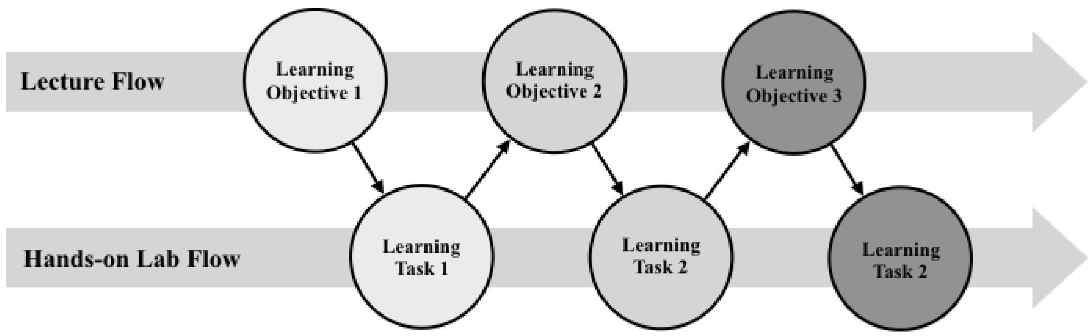

Figure 3.38. Learning Sessions in a Lecture Block.

■ DOUBLE SCOPE TASKS

The age range of adult learners tends to be wide. As a result, the individual experiences and knowledge learners bring to the lecture differ greatly. The lecturer must be aware of this fact and think about how to deal with it.

The core learning scope should be set for each learning session and it should be mandatory for all learners to finish all the learning tasks defined in the core learning scope. It would be nice to check if the learners completed the tasks using an automatic scoring function. It may be difficult for beginners even to handle tasks within the core scope. However, due to differences in levels between learners in many respects, there may be many students who feel that the core learning tasks are not demanding enough.

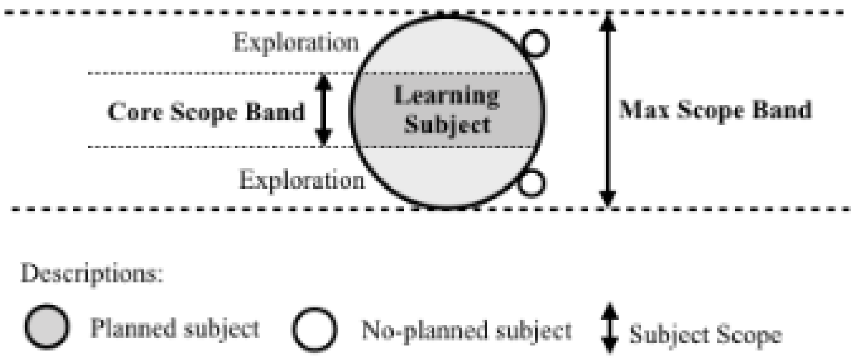

Figure 3.39. Double Scope Tasks.

In order to handle such cases, prepare advanced tasks that can be tackled in the remaining time for the learners who finished core tasks, or prepare equivalent methods. In this way, advanced learners can explore the areas beyond the core scope on their own while allowing other regular learners to work on the tasks within the core scope. Figure 3.39 shows the dual scope of a particular subject. The white circles in the figure represent the learning content covered during the lecture but they are not included as a part of the lecture.

3.5.2 Evaluation Method

First, a story-based lecture for a basic AI course from the past-to-present perspective was created for non-technical adult learners by the proposed method. Then we implemented this course as a blended course and executed the lecture with the flow depicted in Figure 3.40. During the lecture, we collected test scores before and after each lecture block to evaluate the effectiveness of the lecture in terms of the magnitude of the change in the learners' knowledge about the topics.

Table 3.10 shows the list of question items which were asked to the participants via a questionnaire survey.

Table 3.10

Question Items After the Lecture.

Question ID	Question
Q1	Do you think the style of learning Artificial Intelligence while following its history is good?
Q2	Why do you think so?
Q3	How likely are you to recommend this course to your friend?
Q4	Why do you think so?

For the question item Q1, ‘Did you think the style of learning Artificial Intelligence while following its history is good?’, responses were given on a seven-point ordinal scale, ranging from -3-’disagree,’ to +3-agree,’ with 0 representing ‘neither agree nor disagree’. For the question item Q3, ‘How likely are you to recommend this course to your friend?’, responses were given on an 11-point rating scale, ranging from 0 (not at all likely) to 10 (extremely likely).

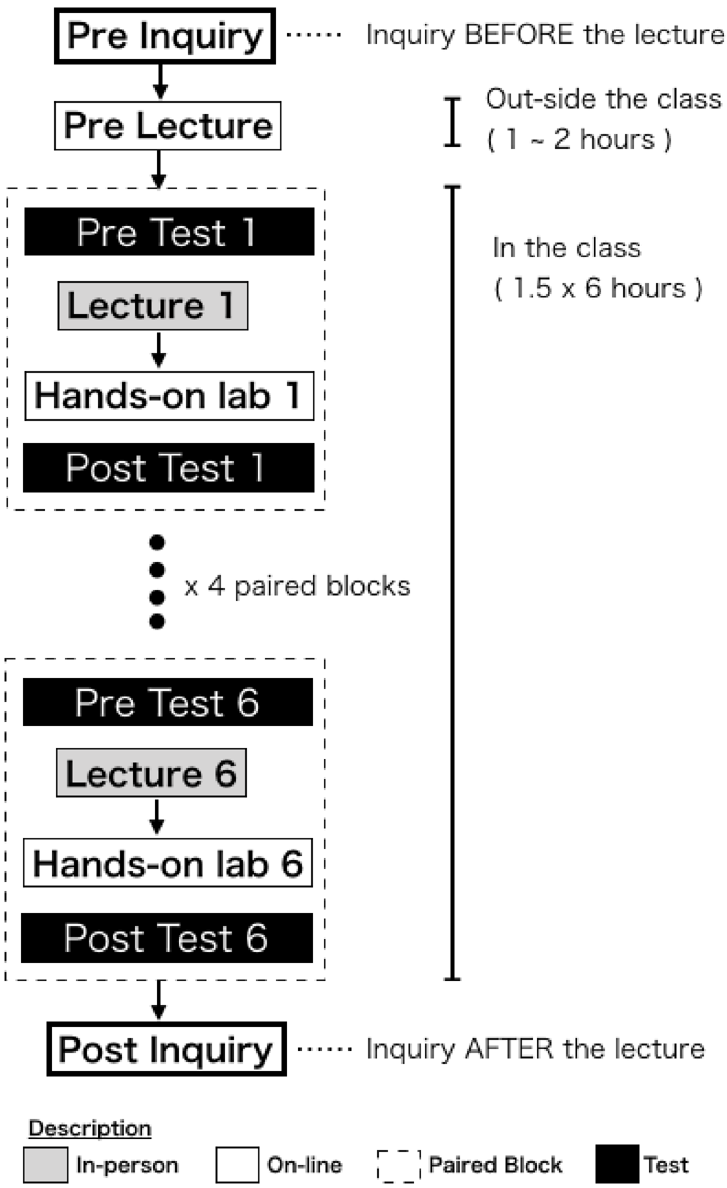

Figure 3.40. Flow of Blended Course

In this study, we used the open-coding method (Kobayashi et al., 2018a) to analyze free descriptive answers with the following procedure.

- Step 1: View the free answers, and pick those related to history. The viewpoint set as “learning AI while following history” and “course satisfaction” for Affinity Diagram grouping, in order to clarify the effect of learning style and the satisfaction of the course.
- Step 2: Look for, from the aforementioned viewpoint, the descriptions related to structuralizing with multiple viewpoints, and sort them into groups.
- Step 3: Write titles for each group that summarizes the essence of the group, at a slightly higher level of abstraction (called “Open coding results” in this study).

In order to ensure the reliability of the open-coding result generated by the authors, we validated the result with an open-coding specialist (Golafshani, 2003).

3.5.3 Evaluation Result and Discussion

- Participants’ Profile

The participants in this lecture were business professionals from a wide range of industries and with different ages, job roles, and different levels of programming skill. In this study, we define a business professional as a person who has a job in a company. Table 3.5.3 summarizes the profiles of the participants.

From the 90 participants, we selected 75 target participants as non-technical adult learners by removing participants who played an engineering role in the office and who had a junior or senior level of programming expertise, because they were close to technical professionals in terms of their programming expertise although she or he served a non-technical role in the office. On the other hand, we removed all the participants who take an engineering role in the office even though they claimed to belong to 'No Experience' and 'Entry level' categories because they might underestimate themselves.

■ History-based Story Result

The following is the result of each step defined by the proposed method for creating story-based lectures.

- Step 1: Set a concrete learning goal. The target learners for this course are non-technical adult learners (members of society who have a job). Mostly, many years have passed since the learners graduated from school. It is assumed that the learners have never followed the program or are at beginner level. Typically, the learners are non-technical workers but, in their role, need to be able to participate in AI discussions. The learning goals are set to 'Be able to explain AI to others' and 'Be able to imagine the technology behind artificial intelligence'. In order to achieve these goals, a concrete final artifact requested in this course is 'A program that recognizes handwritten numbers with Deep Learning'.
- Step 2: Identify chronologically related main topics which are necessary for accomplishing the concrete learning goal. The learning goal expects the concrete artifact that uses Deep Learning to recognize handwritten numbers. Naturally, the chronological order of learning topics becomes 'Logistic Regression', 'Neural Network' and 'Deep Learning'.
- Step 3: Identify sub-topics which are necessary for accomplishing the goals of main topics. Since one of the learning goals is "Be able to imagine the technology behind artificial intelligence" and the expected artifact at the end of the course is 'A program that recognizes handwritten numbers with Deep Learning', the learners need to understand the basics of image, programming, and mathematics.

- Step 4: Temporarily fix main topics and sub-topics as lecture blocks. In this step, fix the following five learning topics extracted so far:
    (1) Deep Learning
    (2) Neural Network
    (3) Logistic Regression
    (4) Programming
    (5) Mathematics
    (6) Image

There is a historical relationship among the main topics (1), (2) and (3). The larger the number is, the older it is. There is no time dependency among the sub-topics (4), (5) and (6). Figure 3.41 shows the result at this point.

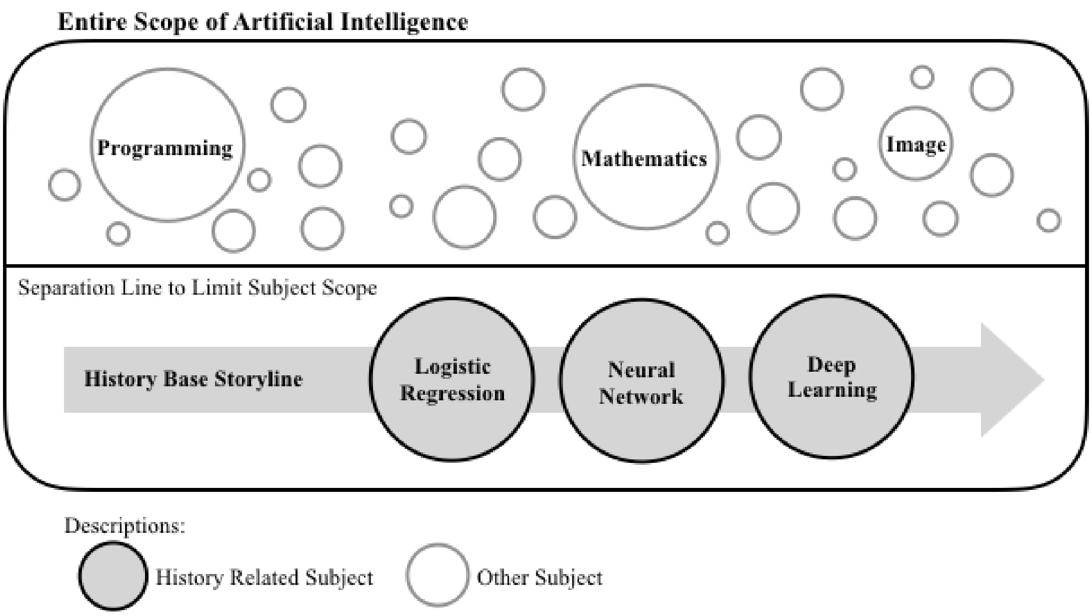

Figure 3.41. Initial Version of History-Based Storyline.

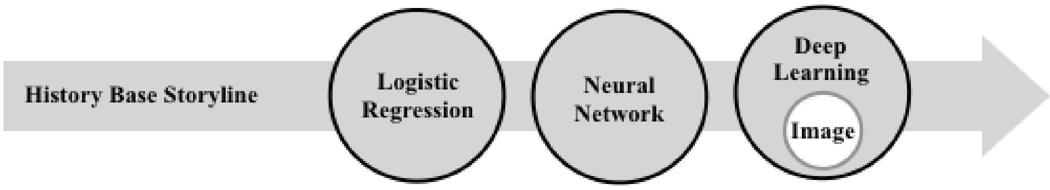

Figure 3.42. Image Topic is Covered in the Deep Learning Topic.

- Step 5: Implement lectures for main topics and arrange the lecture blocks chronologically. Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block becomes too large. Since the sub-topic of “Image” does not take too much time to teach, we decided to teach this topic just before the learners need to work on handwritten images when they are learning about Deep Learning (Figure 3.42). “Programming” and “Mathematics” are too large to put onto the history base storyline. Although it could be possible to divide them into small pieces to insert them into the history base storyline, we did not take that option. Instead, we decided to teach them independently outside the history base storyline for the purpose of learning efficiency.

- Step 6: Implement lectures for large sub-topics as independent lecture blocks.

Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block becomes too large. We decided to teach “Programming” and “Mathematics” online. We expected the learners to finish them by themselves before the in-person lecture. In order to mitigate learning difficulty, we used the visual teaching method (Seya et al., 2020). Figure 3.43 shows the result at the end of Step 6.

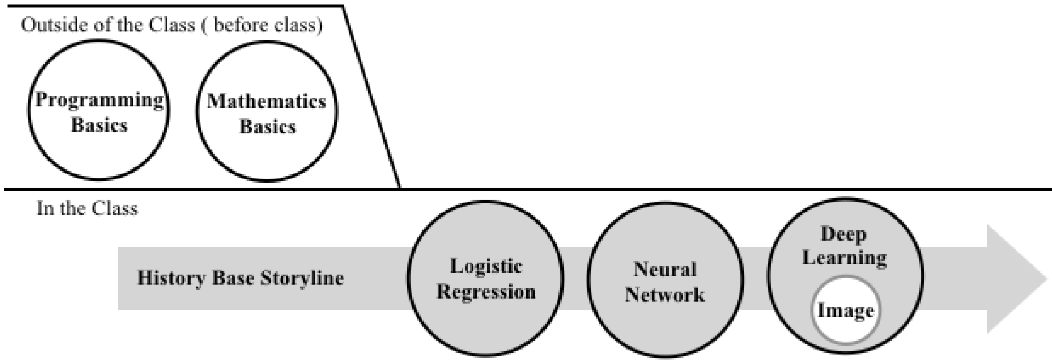

Figure 3.43. Preliminary Design of AI Course.

- Step 7: Implement both core learning tasks for all learners and advanced learning tasks for advanced learners in each lecture block. We implemented the core learning tasks which all learners must work on. For the advanced learners who could explore beyond the prepared exercises, instead of providing challenging exercises, we provided an environment where the learners could freely change their code and try it out after completing core learning tasks. In this way, the learners could play with their code by themselves at their own level (Figure 3.44). This environment was enabled by Jupyter Notebook, which is widely adopted by researchers, data analysts, and even journalists (Rule et al., 2018).

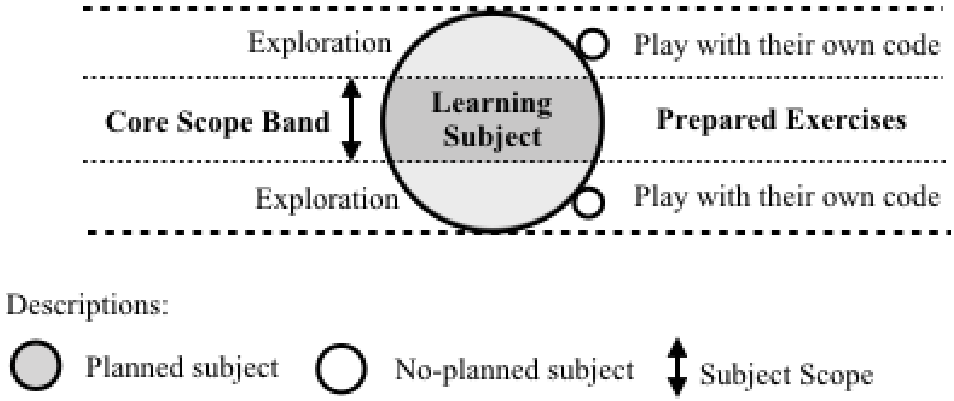

Figure 3.44. Core Learning Tasks and Exploration

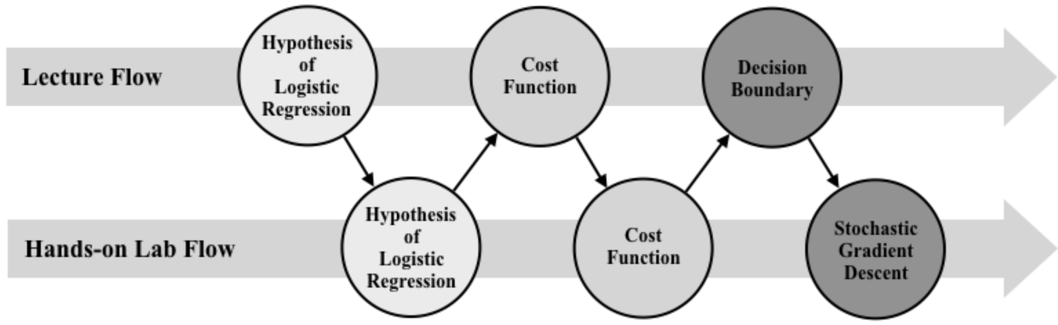

Figure 3.45. Lecture Sessions and Hands-on Sessions for Linear Regression.

In each lecture block, we provided the learning objectives as small, related sessions (Figure 3.45). These sessions were designed to be small to enable the agile teaching method (Seya et al., 2019a).

- Step 8: Fix the lecture blocks if they are not compatible with administrative constraints. Go back to Step 2 if it is necessary to meet the constraints.

Generally, it becomes easier to do more advanced tasks later in the course. However, when the learners have just moved into the session about the neural network from the session about logistic regression, they are only capable of solving a binary problem. In order to recognize handwritten numbers with deep learning, the learners need to know how to solve a multi-class problem because there are ten figures, 0 ~ 9, that need to be recognized and classified. In principle, it is possible to teach how to solve a multi-class problem in the neural network teaching block, but it is not a good idea to do so in practice because the teaching block becomes too large. Similarly, the teaching block for logistic regression turned out to be too large. In order to align with administrative constraints such as the length of the lecture defined by the educational institution, we decided to go back to Step 2 in order to reconfigure the teaching blocks.

- Step 2 (2nd Round): Identify chronologically related main topics which are necessary for accomplishing the concrete learning goal.

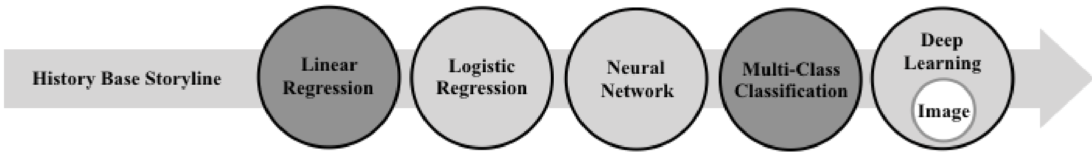

Figure 3.46. Two New Teaching Blocks Added to the History-based Storyline.

We decided to have a teaching block for multi-class classification by taking this session out of the teaching block for the neural network. We placed the teaching block for multi-class classification between the teaching block for the neural network and the teaching block for deep learning. Similarly, we decided to have a teaching block for linear regression separated from the teaching block for logistic regression instead of teaching it as the input for logistic regression. Linear regression is a simple algorithm, but it contains fundamental concepts such as cost function and stochastic gradient descent. Therefore, the teaching block for linear regression also serves the role of establishing fundamentals for the rest of the teaching blocks. Figure 3.46 shows the result at the end of Step 6.

- Step 3 (2nd Round): No change
- Step 4 (2nd Round): Temporarily fix main topics and sub-topics as lecture blocks.

  In this step, fix the following seven learning topics extracted so far:

  (1) Deep Learning
  (2) Multi-Class Classification
  (3) Neural Network
  (4) Logistic Regression
  (5) Linear Regression
  (6) Programming
  (7) Mathematics

- Step 5 (2nd Round): No change
- Step 6 (2nd Round): No change

- Step 7 (2nd Round): No change
- Step 8 (2nd Round): No change
- Step 9 (2nd Round): Place the introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block. Also, place the outline session at the beginning of each teaching block to explain the role of the lecture block in relation to the previous topic.

A session was added to the beginning of each lecture block to clarify the purpose and historical position of the lecture. Figure 3.47 shows the sessions in the lecture block for linear regression as an example. In this diagram, the session, "Linear Regression Overview" is added to the beginning of the teaching block.

In this step, we also placed the introduction of AI, "History of Artificial Intelligence", as the first lecture block to clearly explain the whole picture of the lecture in this block.

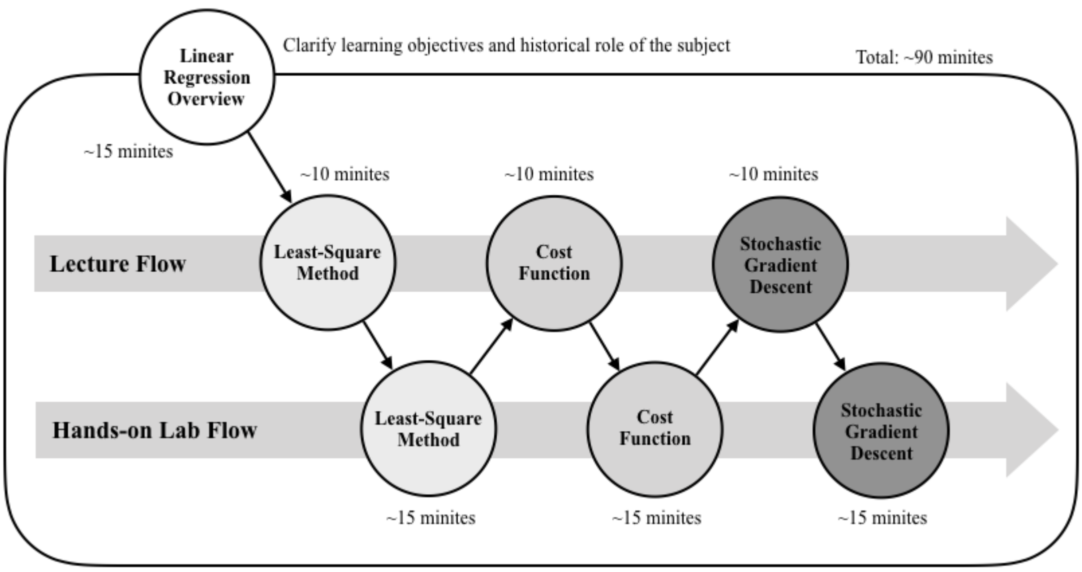

Figure 3.47. Sessions in the Teaching Block for Linear Regression.

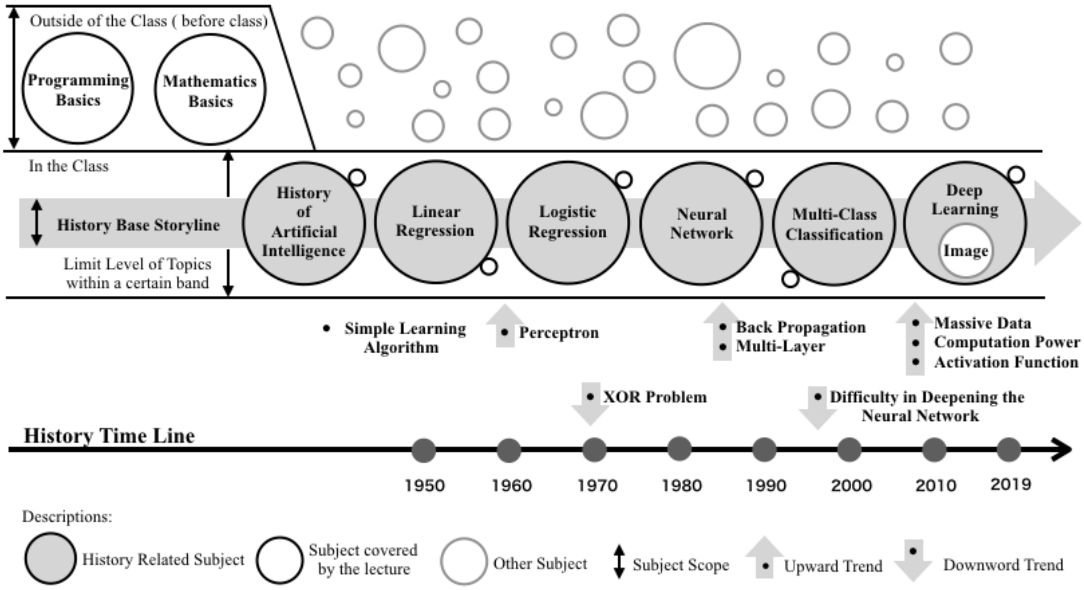

Figure 3.48. Teaching Blocks with the Real History of AI.

The final result of the history-based lecture is depicted in Figure 3.48, with the real history of AI presented at the bottom. Table 3.11 summarizes the lecture flow, topics, and sessions covered in this lecture.

Table 3.11

Lecture Flow, Topics, and Sessions for AI Basic Course

Lecture Flow	**Topics Lecture Block**	**Session 1**	**Session 2**	**Session 3**	**Session 4**	**Session 5**
Pre-Lecture	Programming Basics	Variable, Arithmetic, Array, For-loop, If-statement, Function				
	Mathematics Basics	Vector, Matrix, Logarithm				
Lecture 1	History of Artificial Intelligence	History of Artificial Intelligence	Review of Programming	Review of Mathematics		

Hands-on Lab 1			Review of Programming	Review of Mathematics		
Lecture 2	Linear Regression	Linear Regression Overview	Least-Squares Method	Cost Function	Stochastic Gradient Descent	
Hands-on Lab 2			Least-Squares Method	Cost Function	Stochastic Gradient Descent	
Lecture 3	Logistic Regression	Logistic Regression Overview	Hypothesis of Logistic Regression	Cost Function	Decision boundary	2D Logistic Regression
Hands-on Lab 3			Hypothesis of Logistic Regression	Cost Function	Decision boundary	2D Logistic Regression
Lecture 4	Neural Network	Neural Network Overview	Multi-Layer Perceptron	Back Propagation	Neural Network Model Initialization	
Hands-on Lab 4			Multi-Layer Perceptron	Back Propagation	Neural Network Model Initialization	
Lecture 5	Multi-Class Classification	Multi-Class Classification Overview	Multi-Class Classification	Three Classes Classification & Activation Function	Circle Data Classification	
Hands-on Lab 5			Multi-Class Classification	Three Classes Classification & Activation Function	Circle Data Classification	
Lecture 6	Deep Learning	Deep Learning Overview	Image Data Manipulation	Large Data Manipulation		
Hands-on Lab 6			Image Data Manipulation	Classification of Handwritten Digits		

Table 3.12

Did you think the style of learning Artificial Intelligence while following its history is good?

Scale	**Number of Votes**
-3 (Disagree)	0
-2 (Disagree)	0
-1 (Disagree)	0
0 (Neither agree nor disagree)	2
1 (Agree)	10
2 (Agree)	20
3 (Agree)	43

Table 3.13

How likely are you to recommend this course to your friend?

Scale	**Number of Votes**
0	0
1	0
2	0
3	1
4	1
5	2
6	1
7	16
8	17
9	13
10	24

■ History-based Lecture Favorability and Satisfaction

The responses to the question item Q1, 'Did you think the style of learning Artificial Intelligence while following its history is good?', are summarized in Table 3.12. The responses to the question item Q3, 'How likely are you to recommend this course to your friend?', are summarized in Table 3.13.

■ Open Coding

The open coding results for the free format question item Q2, "Why is it?", which describes the reason for the question item Q1, "Did you think the style of learning Artificial Intelligence while following its history is good?" are shown in Table 3.14.

Table 3.14

Open Coding Result for Question Item Q2.

Open Coding ID	**Open Coding Result**	**Number of Sentences**
HIST_OC_01	Knowledge is easily absorbed because it is accompanied by a story.	9
HIST_OC_02	I think understanding will deepen if there is a background explanation.	17
HIST_OC_03	It is easy to understand how it evolved in order.	10
HIST_OC_04	It's easy to keep it in mind if the reason why the method is needed is understood.	18
HIST_OC_05	By knowing the history, we can see the current issues and the future.	20
HIST_OC_06	It is easy to understand what AI is good at and not good at.	5
HIST_OC_07	The whole structure (the formation of the current form) and the reason why various technologies (inventions) are used are easily understood.	8
HIST_OC_08	My interest in AI increased as I understood why there was a boom (trends up and down).	5
HIST_OC_09	It becomes easier to imagine the situation.	14
HIST_OC_10	As I was able to know the history from the past, I could learn with a sense of reality.	1
HIST_OC_11	Even though I am not good at mathematics, I am interested in history.	3

The open coding results for the free format question item Q4, “Why is it?”, which describes the reason for the question item Q3, “How likely are you to recommend this course to your friend?” are shown in Table 3.15.

Table 3.15

Open Coding Result for Question Item Q4.

Open Coding ID	**Open Coding Result**	**Number of Sentences**
NPS_OC_01	I feel the evolution in history and deepened my understanding with actual programming. I think it is a wonderful program that can be understood even by people who do not know the basics.	5
NPS_OC_02	It would be useful to know what AI is and how it works in my work.	11
NPS_OC_03	I think that it will be easier to imagine artificial intelligence and it can be used in future business.	5
NPS_OC_04	I've read various books so far, but it was much easier to understand than them.	25
NPS_OC_05	I am not very good at math and programming, but I enjoyed it and felt that I wanted to study more.	32
NPS_OC_06	Because you can understand the theory behind it well and it will settle in your brain as you get your hands dirty.	18
NPS_OC_07	By understanding the mechanics of AI, you can obtain the knowledge base you need to think about what you can do with AI.	21
NPS_OC_08	Easy to understand and interesting. You can really understand the essence.	4
NPS_OC_09	Because you can learn the essence of machine learning in a short time.	1

■ Test Scores

Participants took a pre-test before each teaching block started and took a post-test after each teaching block ended. The highest possible score was 800 points. The results of pre-test and post-test are shown in Table 3.16. The result of a paired T-test is shown in Table 3.17 and Figure 3.49.

Table 3.16

Statistics of Post-test and Pre-test.

	Mean	**N**	**Std. Deviation**	**Std. Error Mean**
Post-test	589.18	67	101.618	12.415
Pre-test	188.43	67	98.505	12.034

Table 3.17

Paired T-Test.

ID	**Paired Differences**					**t value**	**Degree of freedom**	**P value (2-tailed)**
	Mean	**Std. Dev.**	**Std. Error Mean**	**95% Confidence Interval of the Difference**				
				Lower	**Upper**			
q01	400.7	121.2	14.80	371.2	430.3	27.08	66	0.000**

** Significant at p < 0.001

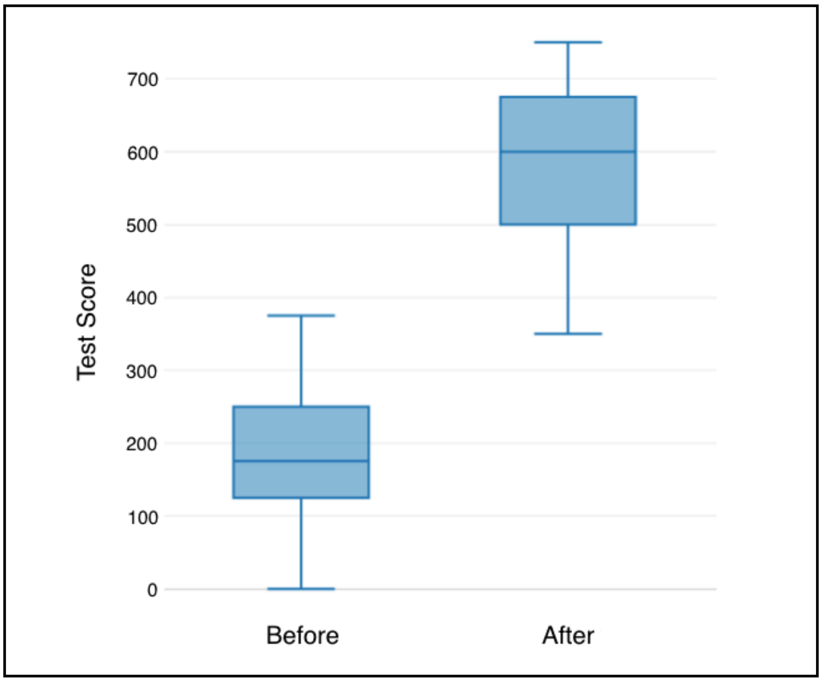

Figure 3.49. Box Plot of Pre-test and Post-test.

Table 3.18

Pearson Correlation Coefficient between Post-test and Net Promoter Scores.

	Correlation Coefficient	**t - Ratio**	**Degree of freedom**	**p-value (2-tailed)**
Post-test Score and Net Promoter Score	0.2724	2.282	65	0.0258*

* Significant at $p < 0.05$

Table 3.19

Pearson Correlation Coefficient between Score Gap and Net Promoter Score.

	Correlation Coefficient	**t - Ratio**	**Degree of freedom**	**p-value (2-tailed)**
Score Gap and Net Promoter Score	0.2445	2.033	65	0.0461*

* Significant at $p < 0.05$

Table 3.18 shows the Pearson correlation coefficient between the post-test score and Net Promoter Score. We also calculated the score gap between the post-test and pre-test and calculated the Pearson correlation coefficient between the score gap and Net Promoter Score, which is shown in Table 3.19. The reason why the degree of freedom is 65 while the number of target participants is 75 is due to missing data; 67 out of 75 participants were able to calculate entrance and exit tests correctly.

3.5.4 Discussion

■ Story-based Lecture

We followed the proposed steps to build a story-based lecture for the basic AI course. Table 3.18 shows the results of all the tasks for building the lecture.

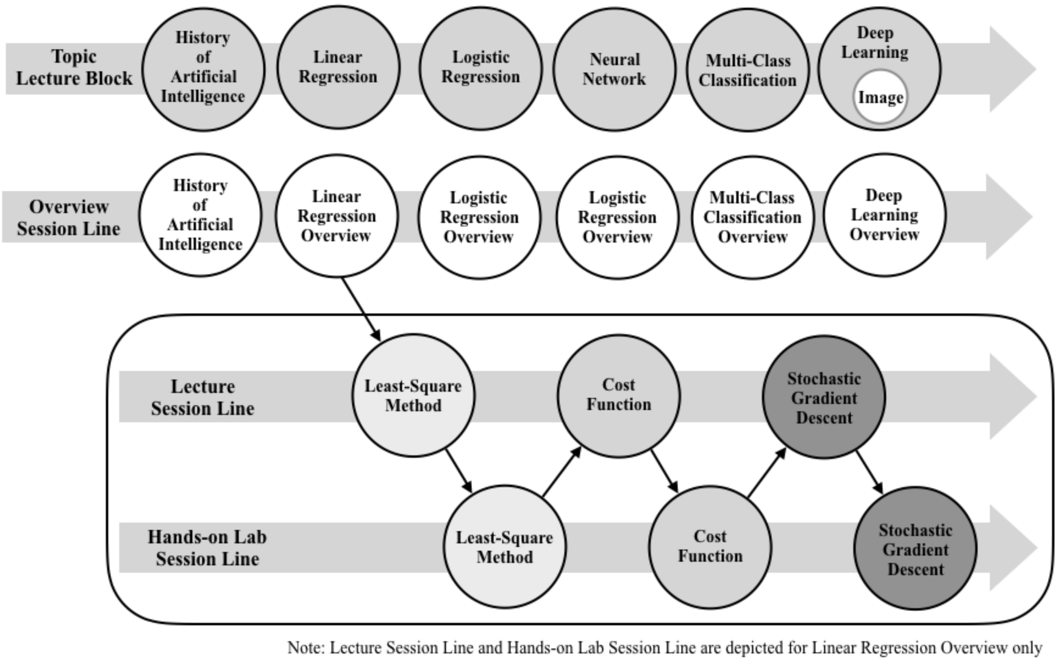

Figure 3.50. Linearized Storyline and Sessions in a Teaching Block

In order to make the story linear, teaching blocks were provided in chronological order. The size of each teaching block (i.e., each topic) was about the same. This feature was naturally embedded in this proposed method because it forced us to make each teaching block small. This would increase the sense of linearity because the feature of linearity can be maintained if the duration is short. Figure 3.50 shows a linearized storyline built with small, chronologically ordered teaching blocks. Sessions in a teaching block for linear regression are also shown in Figure 3.50 as an example of the structure inside each teaching block.

Teaching blocks for basic knowledge of programming and mathematics took about 1 to 2 hours as a task to be completed before a direct lecture given by a lecturer. By asking for the learning tasks to be completed online before the direct lecture, we obtained a secondary effect that all the participants were able to check their PC, which they used in class, before the direct lecture in person. Adult learners might not be used to handling a PC or their PC might be under strict security control by the company they work for, which could result in a network access problem. The lecturer needs to be aware of such administrative problems.

- Learning Style Popularity and Satisfaction

All the responses to the question item Q1, 'Did you think the style of learning Artificial Intelligence while following its history is good?', were above 0; there were no negative responses. The average was 2.39, with the response range on a 7-point scale between -3 and +3. This result indicates that most of the participants liked this style. We categorized effective reasons with the evaluation points on why participants liked this style. Table 3.20 shows the results.

- Satisfaction

The responses to the question item Q3, 'How likely are you to recommend this course to your friend?'', show that the number of promoters who marked 10 and 9 was 39, the number of passive people who marked 8 and 7 was 33, and the number of detractors who marked under 6 was 5. The Net Promoter Score was +45%. The Net Promoter Score is said to give more serious responses with a sense of responsibility by letting respondents think about the future behavior of recommending to close people, not just their own satisfaction. Therefore, it may be considered that she or he is making an objective judgment rather than a mere personal impression. The act of "recommending to people" cannot be done without trust and attachment to the lecture. Therefore, those who answered that she or he would actively recommend have a positive attitude towards the lecture. In other words, it suggests that there is a high possibility that it is linked with a positive intention that leads to the continuation of learning.

Table 3.20

Effective Reasons for Learning Style Popularity.

Effective Reasons	**Evaluation Points**	**Open Coding ID**
Grasp the whole and check the positioning of the learning content.	flow, direction, and position	HIST_OC_05
	whole picture	HIST_OC_07
The story is linearized and easy to understand.	linearization	HIST_OC_03
It is easy to understand because of the causal relationship.	causal relationship	HIST_OC_04
Learning content becomes easy to understand with context given through a story.	story	HIST_OC_01
	context	HIST_OC_02
It becomes easy to imagine.	easy to imagine	HIST_OC_09
It enables comparison.	comparison	HIST_OC_06
It increases interest in the subject.	interest	HIST_OC_08
	history	HIST_OC_11
It gives a real feeling about learning topics.	reality	HIST_OC_10

The reasons the participants were satisfied with the lecture were analyzed by the open coding method over the free format question item Q4, "Why do you think so?" and are summarized in Table 3.14. We categorized effective reasons with the evaluation points on why participants were satisfied with this course. Table 3.21 shows the results. The evaluation points: "understand" and "easy to understand' are similar but we distinguished between them.

Table 3.21

Effective Reasons for Satisfaction.

Effective Reasons	**Evaluation Points**	**Open Coding ID**
I can understand.	History helps in understanding	NPS_OC_01
	understandable	NPS_OC_05
I can imagine the subject.	imaginable	NPS_OC_03
It is easy to understand.	easy to understand	NPS_OC_04
It is practical.	practical	NPS_OC_02
I can feel it.	reality	NPS_OC_06
I can gain knowledge.	knowledge	NPS_OC_07
It is fun to study.	fun	NPS_OC_08
I can learn the subject in a short time.	short time	NPS_OC_09

- Possible Solution for Conversational Programmers

The open coding results in Table 3.13 imply the history-based story linearizes the story, providing causality and context because the results include HIST_OC_02, ”I think understanding will deepen if there is a background explanation.”, HIST_OC_03, ”It is easy to understand how it evolved in order”, and HIST_OC_04, “It's easy to keep it in mind if the reason why the method is needed is understood.” Moreover, history is a story by itself and it is persuasive because it is real. Therefore, the learners can learn the content with reality as one of the open coding results, HIST_OC_10, “As I was able to know the history from the past and I could learn with a sense of reality.” Also, in order to save time for learning it is possible to limit the number of topics taught by restricting the topics to historically important subjects. In this way, the learners can learn the content without falling into too many details.

Table 3.22

Six Common Reasons for Feelings of Failure Among Conversational Programmers When Using Modern Resources (Wang et al., 2018).

Issue ID	**Reasons for Feelings of Failure**	**Description**
i01	Takes too much time	Investing in learning programming ended up requiring more time than participants wanted to devote given their busy schedules.
i02	Too much focus on syntax and logic	Most of the resources focused on programming syntax and logic which did not directly help participants with their technical conversations.
i03	Explanations are not relevant	The conceptual and application-related explanations desired by the participants were not always relevant nor available in the learning resources.
i04	Difficult to assess the content's reliability	Participants did not feel confident enough to assess whether a given resource contained accurate and reliable content.
i05	Feelings of social isolation	Resources and learning environments that target CS students or professional programmers often created feelings of social isolation among participants.
i06	Easy to forget details	It was easy for participants to forget programming definitions and details because they did not apply what they learned directly on-the-job.

For these reasons the following effects could be expected:

(1) Learners can imagine the content being discussed including the context

(2) Linearize the story (intelligible)

(3) It becomes easy to connect the topics before and after in a causal relationship

(4) It is persuasive, and learners can also check the credibility of the content by themselves

(5) Real and substantial value

(6) Easy to understand, focus on the most important outlines and save on learning time

(7) The market value increases if you gain the sense and knowledge that you can use it at work

These benefits can be used to eliminate six problems (Wang et al., 2018) where non-technical adult learners, called conversational programmers, have feelings of failure when learning about technical topics (Table 3.22).

Table 3.23 shows how each open coding result relates to solving the six problems conversational programmers face. The mark, 'O', in Table 3.23 indicates a possible relationship between an open coding result and the issues.

Table 3.23

Why the Approach Solves Six Problems Conversational Programmers Face.

Open Coding ID	**Open Coding Result**	**Issue ID**					
		i01	**i02**	**i03**	**i04**	**i05**	**i06**
HIST_OC_01	Knowledge is easily absorbed because it is accompanied by a story.	O		O		O	O
HIST_OC_02	I think understanding will deepen if there is a background explanation.			O	O		O
HIST_OC_03	It is easy to understand how it evolved in order.	O		O		O	O
HIST_OC_04	It's easy to keep it in mind if the reason why the method is needed is understood.			O	O		O
HIST_OC_05	By knowing the history, we can see the current issues and the future.			O			
HIST_OC_06	It is easy to understand what AI is good at and not good at.			O			

HIST_OC_07	The whole structure (the formation of the current form) and the reason why various technologies (inventions) are used are easily understood.			O			
HIST_OC_08	My interest in AI increased as I understood why there was a boom (trends up and down).			O			
HIST_OC_09	It becomes easier to imagine the situation.	O	O	O			O
HIST_OC_10	As I was able to know the history from the past and I could learn with a sense of reality.			O			O
HIST_OC_11	Even though I am not good at mathematics, I am interested in history.			O		O	
NPS_OC_01	I feel the evolution in history and deepen my understanding with actual programming. I think it is a wonderful program that can be understood even by people who do not know the basics.			O	O	O	O
NPS_OC_02	It would be useful to know what AI is and how it works in my work.			O			
NPS_OC_03	I think that it will be easier to image artificial intelligence and it can be used in future business.			O			
NPS_OC_04	I've read various books so far, but it was much easier to understand than them.	O	O			O	
NPS_OC_05	I am not very good at math and programming, but I enjoyed it and felt that I wanted to study more.		O			O	O
NPS_OC_06	Because you can understand the theory behind it well and it will				O		O

	settle in your brain as you get your hands dirty.						
NPS_OC_07	By understanding the mechanics of AI, you can obtain the knowledge base you need to think about what you can do with AI.			O			
NPS_OC_08	Easy to understand and interesting. You can really understand the essence.	O	O		O	O	O
NPS_OC_09	Because you can learn the essence of machine learning in a short time.	O				O	O

The reasons why each problem can be solved are as follows:

- i01: Takes too much time

(HIST_OC_01) If the story helps and knowledge is easier to keep in mind, less time is spent working

(HIST_OC_03) By linearizing and reducing complexity, there is no return and time can be shortened.

(NPS_OC_07) If learners can get the whole picture, they can focus on just the parts they need and therefore they can reduce learning time.

(NPS_OC_04) If it is easy to understand, it takes less time to understand.

(NPS_OC_05) If learners are willing to learn by themselves, the sense of taking too much time will diminish.

(NPS_OC_08) If it is fun, the feeling that it takes too long will weaken.

(NPS_OC_09) The lecture itself takes a short time.

- i02: Too much focus on syntax and logic

(HIST_OC_09) Reduce learning time by focusing on understanding images rather than remembering details.

(NPS_OC_04) If it is easy to understand, even complex content will not feel troublesome.

(NPS_OC_05) If learners are willing to learn by themselves, it will be easier for them to work on complex content.

(NPS_OC_08) If it is fun, it will be easier to work on complex content.

- i03: Explanations are not relevant

(NPS_OC_01 ~ HIST_OC_11)

(NPS_OC_02) History inevitably becomes deeply related to the subject topic.

(NPS_OC_03) Learners feel that they can actually put it to work by becoming able to imagine the topic.

(NPS_OC_07) Learners feel that they could actually accumulate useful knowledge.

- i04: Difficult to assess the content's reliability

(HIST_OC_02) If the understanding is deepened, learners can confirm the authenticity of the content by themselves.

(HIST_OC_04) If learners understand the reason why the method is needed, they can evaluate the value of the method by themselves.

(NPS_OC_01) If learners can absorb the content, learners can evaluate its reliability by themselves.

(NPS_OC_06) Learners can check the accuracy and credibility of the learning content by themselves.

(NPS_OC_08) If learners have an essential understanding, they can confirm the authenticity of the content by themselves.

- i05: Feelings of social isolation

(HIST_OC_01) If it is easy to acquire knowledge in context, learners won't feel alienation due to the difficulty of the content.

(HIST_OC_11) History is not a technical detail, so everyone is equally welcome to join discussions.

(NPS_OC_01) If the content is selected for beginners, learners feel less alienation due to the difficulty of the content.

(NPS_OC_04) If it is easy to understand, learners won't feel a sense of alienation due to the difficulty of the content.

(NPS_OC_05) If learners feel positive about learning, they will be actively involved in the community.

(NPS_OC_08) If learners find learning interesting, their participation in the community becomes positive.

(NPS_OC_09) The shorter the learning time, the less the mental burden of community participation.

- i06: Easy to forget details

(HIST_OC_01) It is difficult to forget if learners learn the context together.

(HIST_OC_02) It will be difficult to forget if the understanding is deepened.

(HIST_OC_03) Straight and simple stories are easier to remember than complex content.

(HIST_OC_04) It becomes difficult to forget if the reason for the need is understood.

(HIST_OC_09) Image-centric approach eliminates the need to remember details.

(HIST_OC_10) It is difficult to forget content that feels real.

(NPS_OC_01) Focusing on the basic content for beginners, learners won't have to remember complex details.

(NPS_OC_05) If learners feel positive about the content of learning, their mental burden of remembering will also decrease.

(NPS_OC_06) It is difficult to forget what is learned by actually doing.

(NPS_OC_08) If learners find the content interesting, it will reduce the mental burden of remembering.

(NPS_OC_09) If the learning time is short, there is no need to remember the details for a long time, so the burden on memory is reduced.

From the reasons above, we assume it would be possible to solve or reduce the cause of feelings of failure for non-technical adult learners known as conversational programmers. However, due to the limitation of this study, these reasons do not necessarily apply to all conventional programmers.

■ Learning Performance Outcomes

The difference between pre-test and post-test scores was 400.75 points on average, indicating that the knowledge had grown to about +50% of the full score (i.e., 800 points) after the lecture. However, the correlation coefficient between the post-test score and satisfaction was only 0.2724. The correlation coefficient between satisfaction and the growth of the test score (i.e., the difference between pre-test and post-test scores) also showed a weak correlation at 0.2445. This indicates that not only the test results, but also other factors may be related to satisfaction. This result is consistent with other studies (Sockalingam, 2013) (Wu et al., 2015) that find the degree of satisfaction is not always directly related to the test result.

3.6 Story-building Method Suited for Technical People

We will clarify the procedure of story-building method deployed in the study for CPS education (Seya and Shirasaka, 2016) because it tries to train the learners not only to be capable of dealing with the present problems but also to be capable of dealing with the unknown future problems. This type of learning is expected for technical people.

3.6.1 Proposed Method

■ How to create a story from a "present to future" perspective

Table 3.24 shows the procedure of making a story from a "present to future" perspective. The procedure from Step 1 to Step 5 is a design process that determines the frame of a story. The procedure from Step 6 to Step 10 is the implementation process that fills the concrete contents.

Table 3.24

Story making procedure from a "present to future" perspective

Steps	Descriptions
Step 1	Grasp an overall picture of technical topics in the field of the subject
Step 2	Set concrete learning goals
Step 3	Identify main topics which are necessary for accomplishing the concrete learning goal, and map them onto the parts of a story.
Step 4	Identify sub-topics which are necessary for accomplishing the goals of main topics.
Step 5	Temporarily fix main topics and sub-topics as lecture blocks.
Step 6	Implement main topics. Try to implement the main topics allowing the learners to see multiple approaches and different levels of abstraction to solve the problems. Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block does not become too large.
Step 7	Implement lectures for large sub-topics as independent lecture blocks.
Step 8	Implement both core learning tasks for all learners and advanced learning tasks for advanced learners in each lecture block.
Step 9	Fix the lecture blocks if they are compatible with administrative constraints. Go back to Step 3 if it is necessary to meet the constraints.
Step 10	Place an introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block.

3.6.2 Evaluation Method

In order to evaluate the proposed story-building method, we implement a story-based CPS learning material for technical people using the proposed method and see if it yields an effective learning material which meets the needs for technical people. Since the story-building method is abstract, we would find multiple implementation results. However, it is enough for us to confirm if this story-building method generates one of the effective CPS lecture materials suited for technical people.

3.6.3 Evaluation Result

Following is the result of creating a story using a proposed story-building method for the lecture on CPS. The results are presented as the step-by-step procedures; each step corresponds to the same step in the proposed procedure. The proposed procedure of Step 9 indicates the procedure might go back to Step 3 repeatedly. The number of iterations is placed in the parentheses if the step is repeated more than twice.

- Step 1: Grasp an overall picture of technical topics in the field of CPS

  Technical topics that need to be covered in the field of CPS:

  Control, Sensor, Operation, Observe, Process, Data, Network.
- Step 2: Set concrete learning goals

  Build a robot, which can move around autonomously and also is remotely controllable via Network. Collect image data and audio data from corresponding sensors. Monitor the status of the robot on a cloud server around the clock. Use the processed data on the cloud server to control the control system of the robot.
- Step 3: Identify main topics which are necessary for accomplishing the concrete learning goal, and map them onto the parts of a story.
  - **Identify main topics to be covered in the lecture:**

Control, Sensor, Operation, Observe, Process, Data, Network

- **Map the main topics onto the concrete learning goals with a story:**
  - ✧ Make legs to learn how to control motors (Control)
  - ✧ Make eyes to learn how to process image data from the sensor (Sensor, Process, Data)
  - ✧ Make a mouth to learn how to convert text data into the audio data (Process, Data)
  - ✧ Make ears to learn how to process audio data (Sensor, Process, Data)
  - ✧ Make a robot remotely controllable (Observe, Control, Network, Operation)

- Step 4: Identify sub-topics which are necessary for accomplishing the goals of main topics
  - **Sub-topics need to be covered in the lecture:**
    - ✧ How to set up a development environment
    - ✧ How to write a program for the first time
    - ✧ How to control hardware by software
- Step 5: Temporarily fix main topics and sub-topics as lecture blocks.
- Step 6: Implement the main topics. Try to implement the main topics allowing the learners to see multiple approaches and different levels of abstraction to solve the problems. Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block does not become too large.
- Step 7: Implement lectures for large sub-topics as independent lecture blocks.
- Step 8: Implement learning tasks.
- Step 9: After examining if lecture blocks are within time constraints, the lecture block for “How to set up a development environment” turned out to be too long. Go back to Step 3.

- Step 3 (2nd round): No change needed for main topics.
- Step 4 (2nd round): The sub-topic, “How to set up a development environment”, is divided into two sub-topics: “How to set up the hardware” and “How to set up a stand-alone system environment”.
- Step 5: Change the flow of the sub-topic lecture blocks as the result of Step 4:
  - How to set up the hardware
  - How to write a program for the first time
  - How to control hardware by software
  - How to set up a stand-alone system environment
- Step 6 (2nd round): No change needed.
- Step 7 (2nd round): Implement lectures for the new sub-topics: “How to set up the hardware” and “How to set up a stand-alone system environment”.
- Step 8 (2nd round): No change needed.
- Step 9 (2nd round): Fix the lecture blocks if they are compatible with administrative constraints.
- Step 10: Place an introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block.

3.6.4 Discussion

Table 3.25 shows the list of main topics and sub-topics in the evaluation result and in the lecture of Cyber-Physical System (Seya and Shirasaka, 2016). We can confirm the left and right list items on each row on the table covers the same learning topic. For example, the topic about “How to set up the hardware” is covered by “Use a Raspberry Pi for the first time” in the lecture for Cyber-Physical System. The same is true for the rest of the table items. Therefore, we could conclude that the proposed method was able to generate at least one of the effective stories suited for technical people learning CPS.

Table 3.25

List of main topics and sub-topics

Evaluation Result	Cyber-Physical System (Seya et al., 2016)
How to set up the hardware	Use a Raspberry Pi for the first time.
How to write a program for the first time	Craft a Program for the first time.
How to control hardware by software	Flash an LED with a program.
How to set up a stand-alone system environment	Make a stand-alone robot environment.
Make legs to learn how to control motors	Make legs.
Make eyes to learn how to process image data from the sensor	Make eyes.
Make a mouth to learn how to convert text data into the audio data	Make a mouth.
Make ears to learn how to process audio data	Make an ear.
Make a robot remotely controllable	This topic is covered across the topics after "Make a stand-alone robot environment".

CHAPTER 4:
RESULT AND DISCUSSION

4.1 Difference of Story-building Methods for Learning Materials

Now we have two types of story-building methods discussed in Chapter 3. For the rest of this chapter we call the type of a story created from a "past to present" as Type 1 and call the type of a story created from a "present to future" as Type 2. Table 4.1 shows the corresponding steps on the right and left so that the tasks on Type 1 and Type 2 procedures can be compared easily. In Table 2, the procedure of Type 1 (Seya et al., 2019) starts from Step 2 because there's no explicit equivalent of Step 1 of Type 2 in the procedure of Type 1.

Table 4.1

Comparison of steps for making Type 1 and Type 2 stories

	Past to Present (Type 1)	**Present to Past (Type 2)**
Step 1	(There is no explicit statement which corresponds to the Step 1 in Type 2)	Grasp an overview of technical objectives in the field
Step 2	Set a concrete learning goal.	Set a concrete learning goal
Step 3	Identify chronologically related main topics which are necessary for accomplishing the concrete learning goal.	Identify main topics which are necessary for accomplishing the concrete learning goal and map them onto the parts of a story.
Step 4	Identify sub-topics which are necessary for achieving the goals of main topics.	Identify sub-topics which are necessary for accomplishing the goals of main topics.
Step 5	Temporarily fix main topics and sub-topics as lecture blocks.	Temporarily fix main topics and sub-topics as lecture blocks.
Step 6	Implement main topics as chronologically ordered lecture blocks. Try to implement a sub-topic inside a closely related main lecture	Implement main topics. Try to implement the main topics allowing the learners to see multiple approaches and different levels of

	block unless the volume of the main lecture block does not become too large.	abstraction to solve the problems. Try to implement a sub-topic inside a closely related main lecture block unless the volume of the main lecture block does not become too large.
Step 7	Implement lectures for large sub-topics as independent lecture blocks.	Implement lectures for large sub-topics as independent lecture blocks.
Step 8	Implement both core learning tasks for all learners and advanced learning tasks for advanced learners in each lecture block. Learning tasks should be broken down to small learning blocks related to each other to enable the agile method.	Implement both core learning tasks for all learners and advanced learning tasks for advanced learners in each lecture block.
Step 9	Fix the lecture blocks if they are compatible with administrative constraints. Go back to Step 3 if it is necessary to meet the constraints.	Fix the lecture blocks if they are compatible with administrative constraints. Go back to Step 3 if it is necessary to meet the constraints.
Step 10	Place an introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block. And place an outline session at the beginning of each lecture block to explain the role of the lecture block in relation to the previous topic.	Place an introduction of the subject as the first lecture block and explain the whole picture of the lecture in this block.

4.1.1 First Order Difference

We evaluated the difference in making stories between Type 1 and Type 2, which are described in Table 4.1. In each step described in Table 4.1, if there is a clear difference in the task description at the sentence level, we call such a difference, “Primary difference”. In other words, if the descriptions on the right and left in Table 4.1 for a specific step are clearly different at the sentence level, we consider "there is a primary difference in the step".

Table 4.2

Primary differences in making a story

Difference ID	**Step**	**Presence of Primary Difference**	**The primary difference between Type 1 and Type 2**
Diff1_1	Step 1	YES	Type 1 does not explicitly include this step to grasp an overview of technical topics in the field. Since Type 2 aims at fostering experts, it is necessary to grasp the whole picture at the first stage, and to identify the technical topics that may be necessary to work with unknown problems in the future, even though they are not necessary at present.
	Step 2	NO	
Diff1_2	Step 3	YES	When identifying technical main topics for Type 1, the chronological or logical relationship among the topics is explicitly considered. For Type 2, the coverage of technical topics is more important than the chronological or logical relationship among the topics because the learners need to work with unknown problems in the future.
	Step 4	NO	
	Step 5	NO	
Diff1_3	Step 6	YES	The implementation of main topics is done with low abstraction levels for Type 1. High-level abstraction solutions are also considered for Type 2 because the learners need to learn multiple approaches to work with unknown problems in the future.
	Step 7	NO	
	Step 8	NO	
	Step 9	NO	
	Step 10	NO	

Comparative evaluation for the primary difference is self-explanatory because there is a clear difference at the sentence level in the descriptions on the left and right in Table 4.1. The evaluation results are summarized in Table 4.2.

There are additional descriptions on Step 8 and Step 10 in Type 1. However, we did not consider them as the sentence level difference but see them as the additional descriptions which are based on the second-order difference. The following section explains what the second-order difference is.

4.1.2 Second Order Difference

As the left and right descriptions on each procedural step in Table 4.1 are clearly different in Step 2, Step 4 and Step 5, it is obvious that there is a primary difference in these steps. On the other hand, Step 2, Step 4, Step 5, Step 7, Step 8, Step 9 and Step 10 shown in Table 4.1 are equivalent at the sentence level, and there is no primary difference in these steps. However, even though the same word is used in the sentence, the meaning changes depending on the context in which the word is used (Requejo, 2007). For example, the word "black" used as a color in some context and the same word "black" is used to indicate a "bad" sign in another context. Therefore, even if the descriptions in each step are the same at the sentence level, the meaning of descriptions may be different if the context is different. We define this level of difference as a second-order difference.

From the evaluation of primary differences in Table 4.2, we observe the common reason that makes such differences i.e. "whether the learners need to learn the technologies to work with unknown problems in the future." We take this common reason as the context between Type 1 and Type 2 because it is commonly found behind the comparison and it directly affects what needs to be done in each step on Type 1 and Type 2.

Table 4.3

Second-order difference between Type 1 and Type2

Difference ID	**Step**	**Second-order difference between Type 1 and Type2**
Diff2_1	Step 2	A fixed application is selected for Type 1. A generic application which allows multiple ways of implementation is selected for Type 2.
Diff2_2	Step 7	The contents in the sub-topics for Type 1 should be minimal. The contents in the sub-topics for Type 2 could be very rich.
Diff2_3	Step 8	Learning tasks for Type 1 are intentionally designed to have a link with the previous task while those for Type 2 are not related to each other.
Diff2_4	Step 10	For Type 2, placement of an outline session at the beginning of each lecture block is not necessary.

Since the context defines the meaning of the words, the tasks on each step in Table 4.1 would be different even though the task descriptions are the same at the sentence level. For example, the task description, “Set a concrete learning goal”, on Step 2 is the same for both Type 1 and Type 2, therefore, there is no primary difference between them. However, the goals for Type 1 and Type 2 are different because their contexts are different. While the goal for Type 1 is to guide the learners to its goal with a fixed single path, the goal for Type 2 is to provide multiple possible solutions to achieve its goal; this is a second-order difference, Diff2_1, found in Table 4.3. The other second-order differences are also summarized in Table 4.3, which are found in Step 2, Step 7, Step 8, and Step 10.

4.2 Features of Learning Materials for Non-Technical People

The first obvious difference between Type 1 and Type 2 is that the story creation process for Type 1 does not have an explicit step to grasp an overview of technical topics in the field.

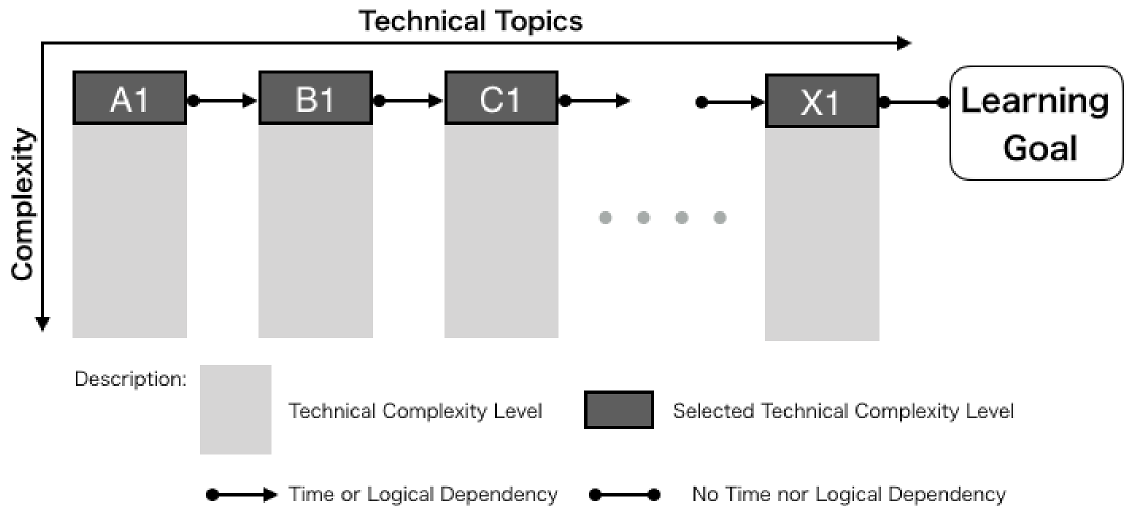

Figure 4.1. Learning Topics in Type 1

We could consider this as a manifestation of the fact that the need to completely investigate technical topics is not critically important for Type 1 because, it is not important for non-technical learners to cover as many solutions as possible to cope with unknown problems in the future.

For Type 1, the selected technical main topics have chronological or logical relationships among them; in other words, they are coherent. The connections between the topics are carefully designed so that the story becomes linear. The learning topics are technically simple, and the number of them are minimal to achieve the goal (Figure 4.1). In Figure 4.1, we can observe that Type 1 is constructing a virtually simple linear story.

4.3 Features of Learning Materials for Technical People

On the other hand, the story creation process for Type 2 has an explicit step i.e. Step 1 to grasp an overview of technical topics in the field. The direct reason why this step is explicitly necessary for Type 2 is because it is a prerequisite for the work in Step 3.

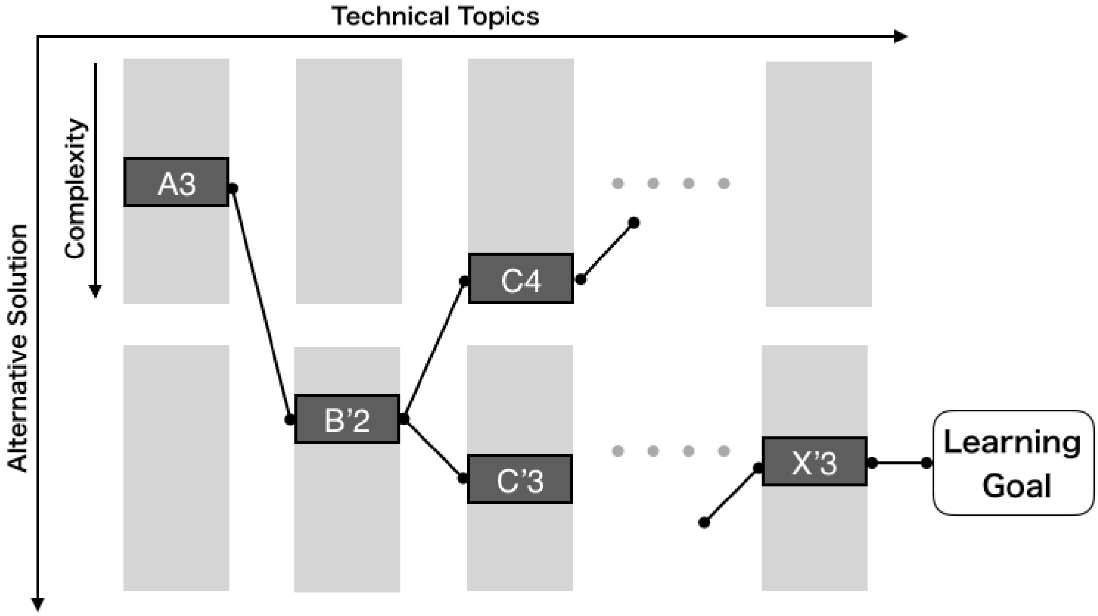

Figure 4.2. Learning Topics in Type 2

For Type 2, not only the technical topics currently required but also the technical topics that may be required in the future are candidates for the main topics in Step 3, therefore it is necessary to look over all the important technical topics in the field.

In general, there are several solutions for solving a technical problem. Therefore, the learner who wants to be an engineer needs to be familiar with these multiple solutions. The learners will also need to learn how to approach a problem using different complexity and abstraction levels. For these reasons, Type 2 expands the choice of creating stories in three dimensions: technical topics, complexity, and alternative solutions (Figure 4.2).

For Type 2, the coverage of technical topics is more important than the chronological or logical relationship among the topics. That would make the learners feel uncomfortable because the technical topics tend to be unrelated to each other and difficult to find meaningful connections among the technical topics by the learners themselves. Indeed, the synthesis of what has been learned in each technical topic to achieve the learning goal is left to the learners in Type 2. For that reason, if the Type 2 story is used, it takes time for the learners to learn a wide range of technical topics in-depth and to synthesis what they have learned to achieve the goal. However, the learners who go through Type 2 story are more likely to be able to explore different solutions in the future when tackling unknown problems. On the other hand, Type 1 basically teaches only a minimum number of important solutions with a provided linear story. As a result, the learners who go through Type 1 story can save their learning time and see the important ideas clearly.

4.4 Possibility of Solving the Issues of Conversational Programmers

Conversational programmers are non-technical people who do not write programming code but want to learn how to program in order to be capable of participating in technical discussions and to increase the market value of themselves. Wang et al. studied conversational programmers' learning approaches and struggles and found the six common reasons why modern learning resources designed for technical people make them feel failures and opened the path for future research to find the solution for mitigating such failures (Wang et al., 2018). Table 4.4 shows a list of six failures.

We discuss a possible approach to solve conversational programmers' issues by leveraging our findings about the differences between Type 1 and Type 2 appeared as primary differences and second-order differences.

While Type 1 story only expands to a single chronological or logical direction as it is described in Figure 2, Type 2 story not only expands to that direction but also to the alternative solution and complexity direction as it is described in Figure 4.2. This situation is depicted in Figure 4.3. In Figure 4.3, Selection 1 is the operation to reduce the number of solution alternatives and Selection 2 is the operation to reduce the complexity of each technical topic.

Table 4.4

Six common reasons for feeling of failure among conversational programmers when using modern resources. (Wang et al., 2018)

Issue ID	Reasons for Feelings of Failure	Description
i01	Takes too much time	Investing in learning programming ended up requiring more time than what participants wanted to devote given their busy schedules.
i02	Too much focus on syntax and logic	Most of the resources focused on programming syntax and logic which did not directly help participants with their technical conversation.
i03	Explanations are not relevant	The conceptual and application-related explanations desired by the participants were not always relevant nor available in the learning resources.
i04	Difficult to assess the content's reliability	Participants did not feel confident enough to assess whether a given resource contained accurate and reliable content.
i05	Feelings of social isolation	Resources and learning environments that target CS students or professional programmers often created feelings of social isolation among participants.
i06	Easy to forget details	It was easy for participants to forget programming definitions and details because they did not apply what they learned directly on-the-job.

A connection is an operation to set the context between the technical topics to connect them chronologically or logically. If the connections are carefully designed, the learners can follow the learning path without needing to find the path to achieve the learning goal by themselves.

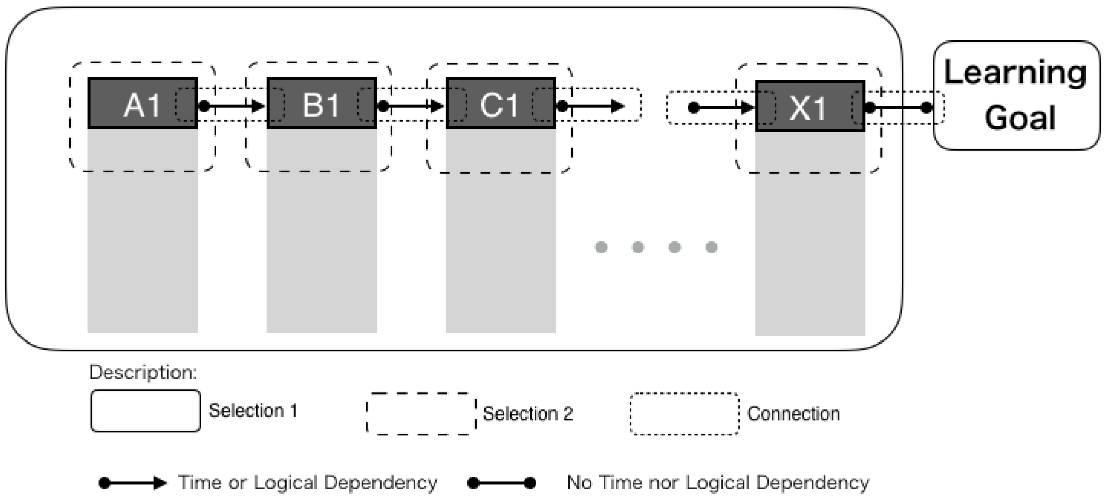

Figure 4.3. Operations in Type 1

Table 4.5 shows how each operation in Type 1 is associated with the conversational programmers' issues as the solution. It is O-marked where the operation can be a solution to the issue.

Table 4.5

Operation as a solution to the issues

Operation	Description	Issue ID					
		i01	***i02***	***i03***	***i04***	***i05***	***i06***
Selection 1	Reduce the choice of multiple solutions	O				O	
Selection 2	Reduce complexity and abstraction choices	O	O		O	O	O
Connection	Organize chronological or logical stories			O		O	O

Following are the list of operations and issue IDs with the reasons why they are O-marked in Table 4.5. The id in the parentheses is the Issue ID in Table 4.5.

- **Operation: Selection 1**
  - (i01) Time is reduced by the limited learning scope.
  - (i05) Because the learning scope is limited, the learners can feel that they can participate in discussions.
- **Operation: Selection 2**
  - (i01) By limiting the learning tasks, the learning scope is further reduced than Selection 1.
  - (i02) The learners only learn the syntax and logic they need to achieve the learning goal.
  - (i04) Since the scope of each learning topic is limited and typical, the credibility of the learning contents can be investigated by the learners.
  - (i05) Since the scope of each learning topic is limited, learners are less likely to get lost in the discussions.
  - (i06) Lectures are designed to teach only the minimum necessary to achieve a learning goal, so there are fewer things to remember to complete a lecture.
- **Operation: Connection**
  - (i03) Since the learners are taught only the minimum necessary to achieve the learning goal, they feel everything they learn is relevant to achieve the goal.
  - (i05) Since the relationship between the learning topics is structured, and the alternative links are eliminated for the sake of simplicity, the learners are less prone to get lost in the discussions.
  - (i06) The learning topics are not separated, but they make up a single story, making them easy to remember for the learners.

By the way, the difference (Difference ID) between Type 1 and Type 2 that was revealed from the comparison of this study affects the three operations of “Select 1”, “Select 2”, and “Connect”. Following is the reason why those operations are affected by the difference between Type 1 and Type 2 from the Type 1 perspective:

- **Diff1_1:**
  - Selection 1: The most typical and necessary minimum technical elements will be selected.
  - Connection: A chronological or logical connection is envisaged.
- **Diff1_2:**
  - Connection: Chronologically or logically related main topics are selected.
- **Diff1_3:**
  - Selection 2: Learning tasks with a low level of complexity and abstraction are selected.
- **Diff2_1:**
  - Connection: The goal is achieved with a chronologically or logically connected structure.
- **Diff2_2:**
  - Selection 2: Select the minimum learning tasks required for the subtopic lecture.
- **Diff2_3:**
  - Selection 2: In the implementation of the exercise, the minimum necessary exercises are implemented as a core exercise group, and for learners who are a little more advanced, the extended exercises relevant to the core exercises are provided.
- **Diff2_4:**
  - Connection: The first lecture is a chronological overview of the subject

Table 4.6

Effect of Differences in how stories are created upon the conversational programmers' problems

Difference ID	Selection 1	Selection 2	Connection	Issue ID					
				i01	***i02***	***i03***	***i04***	***i05***	***i06***
Diff1_1	O		O	O		O		O	O
Diff1_2			O			O		O	O
Diff1_3		O		O	O		O	O	O
Diff2_1			O			O		O	O
Diff2_2		O		O	O		O	O	O
Diff2_3		O		O	O		O	O	O
Diff2_4			O			O		O	O

Therefore, the difference between Type 1 and Type 2 affects the problem of the conversational programmer as a result of affecting the three operations “Selection 1”, “Selection 2”, and “Connection”. For the above reasons, the more prominent these differences are, that is, the more prominent the Type 1 features, the higher the probability that the problem of the conversational programmer can be solved. Table 4.6 summarizes which operations are affected by the difference between Type 1 and Type 2, and as a result, which conversational programmer's problem (Issue ID) is likely to be solved.

4.5 General Difference of Learning Materials from Multiple Viewpoints

Table 4.7 shows the relative and general differences between Type 1 and Type 2 from multiple viewpoints. The viewpoints are listed at the left end of Table 4.7, and the reasons are shown at the right end.

This comparison is relative and general but provides additional insights over the difference of the story types because it leads us to think the difference in a larger context than a teaching material context. Moreover, Table 4.7 could be used as a general guide for selecting an appropriate story type in achieving a given educational goal.

Table 4.7

Comparison of Type1 and Type2 from multiple viewpoints

Viewpoint	**Past to Present**	**Present to Future**	**Reason**
Learning Time	short	long	Diff1_1, Diff1_3, Diff2_2, Diff2_3
Story clarity	clear	unclear	Diff1_1, Diff1_2, Diff2_1
Ease of remembering	easy	difficult	Diff1_2, Diff1_3, Diff2_2, Diff2_3
Number of technical topics	few	many	Diff1_1
Technical depth	shallow	deep	Diff1_3
Flexibility for unknown challenges	small	large	Diff1_1, Diff1_3
Ease of making teaching materials	difficult	easy	Diff1_2, Diff2_3
Versatility of teaching materials	small	large	Diff1_2, Diff1_3, Diff2_3
Dependence on learner experience	large	small	Diff1_2, Diff1_3

4.6 How to Expand the Learning Materials Online Environment

Since we live in the internet age, quite a few researches have been done on how to use the information technology for the effective education. Online education provides flexible options for learners in terms of time, place and pace of their study. For that reason, on-line education naturally used in the context of scalable education. In Chapter 3.4 we identified five issues faced by technical people in completing fully automated online courses on Machine Learning and Deep Learning on their own with a good understanding of both AI theory and its implementation. These identified issues provide us a scaffold to think about what could happen with non-technical adults if they learn an emerging technology in the fully automated on-line learning environment.

One of the unique characteristics of emerging technologies is that the rate of changing in its knowledge is faster than that of established technologies. Because of that, it is even difficult for technical people to catch up with the latest technical topics. It seems reasonable to assume that the challenge for non-technical adults to learn emerging technologies is even harder. The first identified issue with the fully automated on-line course for technical people suggests that it should be a good idea to check the learners' initial knowledge about mathematics and programming. First of all, we can reasonably assume that the mathematical knowledge and programming skill are not solid for the most of business professionals. Therefore, the learning materials needs to cover a minimum set of the required skills. This could be done by preparing learning materials with the story-based teaching method proposed in Chapter 3.4.

The second identified issue is that it is highly possible for the people who does not have basic skills ask for personal support a lot. It is not always possible to provide high quality personal support in the on-line education environment because we cannot predict how many learners will take the course and when the learners take the course. In order to get around such a problem, several methods such as peer-review, discussion group, and automated grading have been tried in the field. Such efforts could mitigate the pain of learning process. However, the research found that the fundamental problem is that the learners who are in trouble sometimes do not know what they don't know. The future research needs to explore how to support such learners on-line.

The third identified issue is that it is difficult for learners to shorten their time spent on the exercises because the time spent between the exercises is almost the same among the learners regardless of their pretest score. This could be a problem for business professionals because they typically cannot secure enough time for learning the topics outside of their domain. It suggests that the designer of the course material needs to consider the number of exercises to be minimum.

The fourth identified issue is that it is necessary to pay attention to the size of the variance of the number of trials on each exercise in order to judge which exercises need to be improved. It seems reasonable to assume that this issue could be true to the non-technical adults too, but the future research needs to confirm it.

The fifth identified issue is that in order to make a smooth transition between AI knowledge and practical exercises, basic versions of practical programming exercises in advance helps learners. This could be a problem for the business professionals because they cannot spend enough time to make themselves familiar with the technology that much. It suggests that the exercises should be provided for the business professionals just good enough to capture the essence of the technology.

CHAPTER 5:
CONCLUSION

This chapter provides the conclusions drawn from the results and discussions in Chapter 4. The conclusions are threefold. First, the revealed features indicate that it is not a small step strategy that helps non-technical adult learners, but it is a big step strategy that traces the outline of the subject. Second, the new perspective has broad applicability and could be widely used in other fields deductively. Third, the application of this study is practical and convenient for educational practitioners when making decisions about the type of materials they provide.

The following sections describe each conclusion in detail followed by the research's limitations and possible future research directions.

5.1 Big Step Strategy

The revealed story-building features depicted in Figure 4.1 indicate that it is not a small step strategy that helps non-technical adult learners because the elements of the story are not selected for the purpose of teaching technical details but selected for the purpose of forming the outline of the whole story linearly, in big blocks. It is completely a different approach that follows a small step strategy which is widely accepted as a teaching method for beginners, because breaking a task into small steps makes the task manageable allowing learners to make steady progress.

The analogy of making a figure with two different approaches seems to best explain this difference, as depicted in Figure 5.1. While the small step strategy builds the figure by stacking small blocks, the big step strategy builds the figure by drawing an outline of the figure first and then digging out the figure along the outline. Drawing the outline of the figure corresponds to making a story for learning material for adult learners.

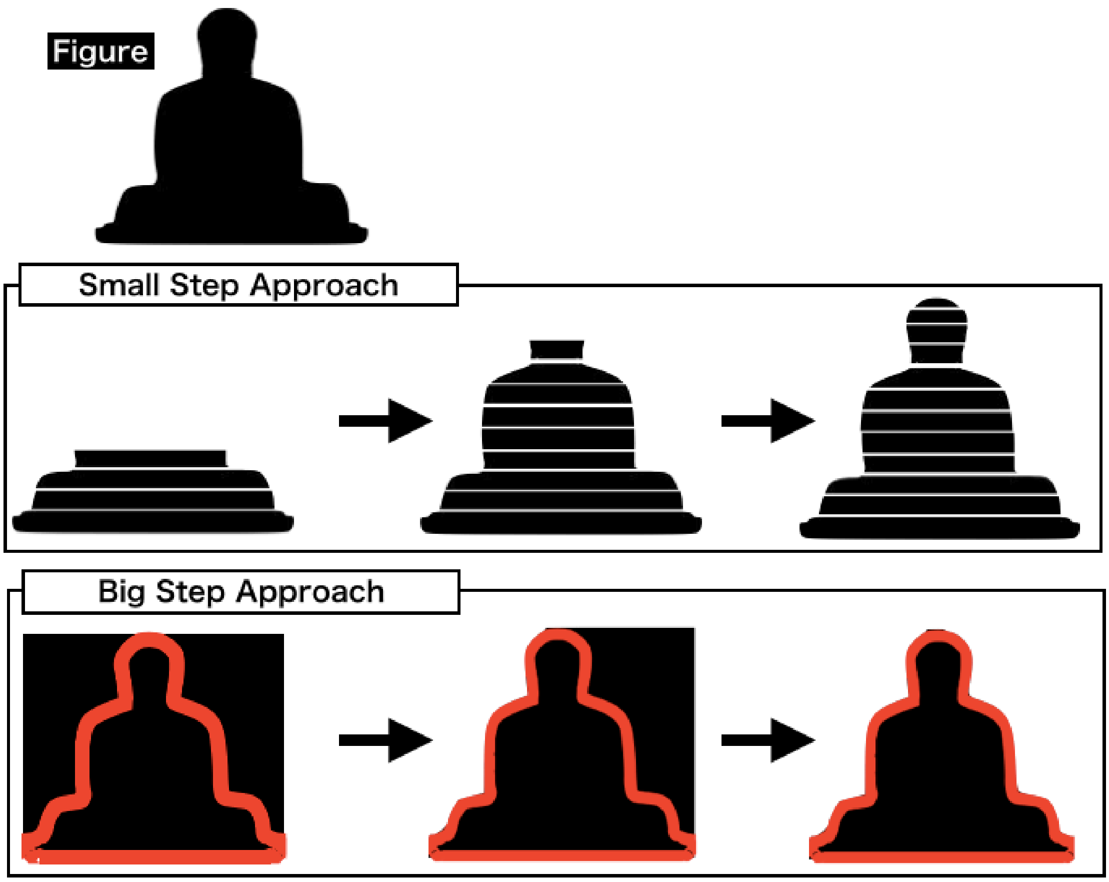

Figure 5.1. Two approaches to make a figure

5.2 Perspectives for the Classification of Groups of People

The proposed two perspectives, "past to present" and "present to future", revealed the features of learning materials suited for non-technical adult learners by comparing the two stories: the one suited for non-technical people created from a "past to present" perspective and the other one suited for technical people created from a "present to future" perspective.

These perspectives can be used as a new axis on which to classify conversational programmers clearly, as depicted in Figure 5.2, which was difficult to do due to the unmappable characteristics of conversational programmers, as depicted in Figure 1.4.

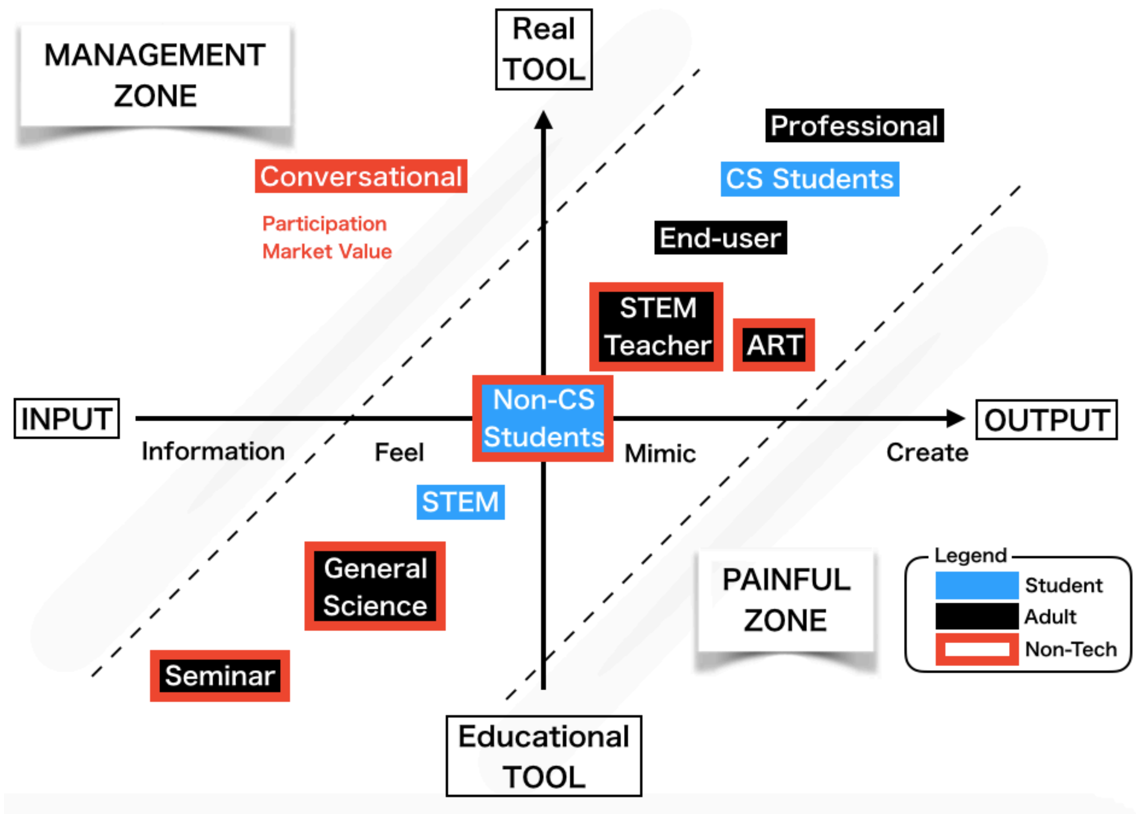

Figure 5.2. Separation of conversational programmers with a new axis

In Figure 5.2, the keyword, "past to present," on the far-left side of the horizontal axis corresponds to "Input," and the other keyword, "present to future," on the far-right side of the axis corresponds to "Output" because the learners who use the learning materials created from a past to present perspective are not required to go beyond input-only learning outcome, while the learners who use the learning materials created from a present to future perspective are expected to make outputs. On the other hand, the vertical axis represents the level of tools the learners use; a higher position on the axis means the use of more advanced tool; a lower position means the use of more educational tool (note that the keyword "educational" is used to indicate "easy" in Figure 5.2 while the same keyword "educational" is used to indicate "learning" in chapter 3.3.)

Conversational programmers do not have to create any artifacts but need to understand what the professionals are doing in the field. Therefore, when they learn programming, they are not satisfied with the use of an educational tool like Scratch which is not used in the real field. For that reason, conversational programmers appear in the second quadrant in Figure 5.2.

It is worth mentioning that the horizontal axis which represents the new perspectives can be used to classify not only conversational programmers but also a group of people who fall into the second quadrant. One group of people located in this quadrant is management because the role of managers is not to create new artifacts but to communicate with the people they manage. That's the reason why the second quadrant is called "Management Zone" in Figure 5.2.

Indeed, as society becomes increasingly complex and dynamic, making conversation with experts in the areas where deep practice plays an important role has become increasingly difficult for inexperienced managers due to a lack of real experience in the field. Such managers are located in this management zone and identified as conversational programmers in the study of Chilana (2015).

The purpose of this dissertation was to understand the features of emerging technology learning materials suited for non-technical adults in the management zone. It is a well-known fact in Andragogy that one of the challenges for adults in this zone is to secure time for learning. For that reason, the learning material for people in the management zone needs to be designed to meet short-learning-time requirements.

Learning time constraints vary from situation to situation, but it is reasonable for people in the management zone to invest as little time as possible, for example, within a one- or two-day time budget. It is possible to analyze this situation using the horizontal axis introduced by the proposed perspectives, with the vertical axis representing learning time budget, as depicted in Figure 5.3.

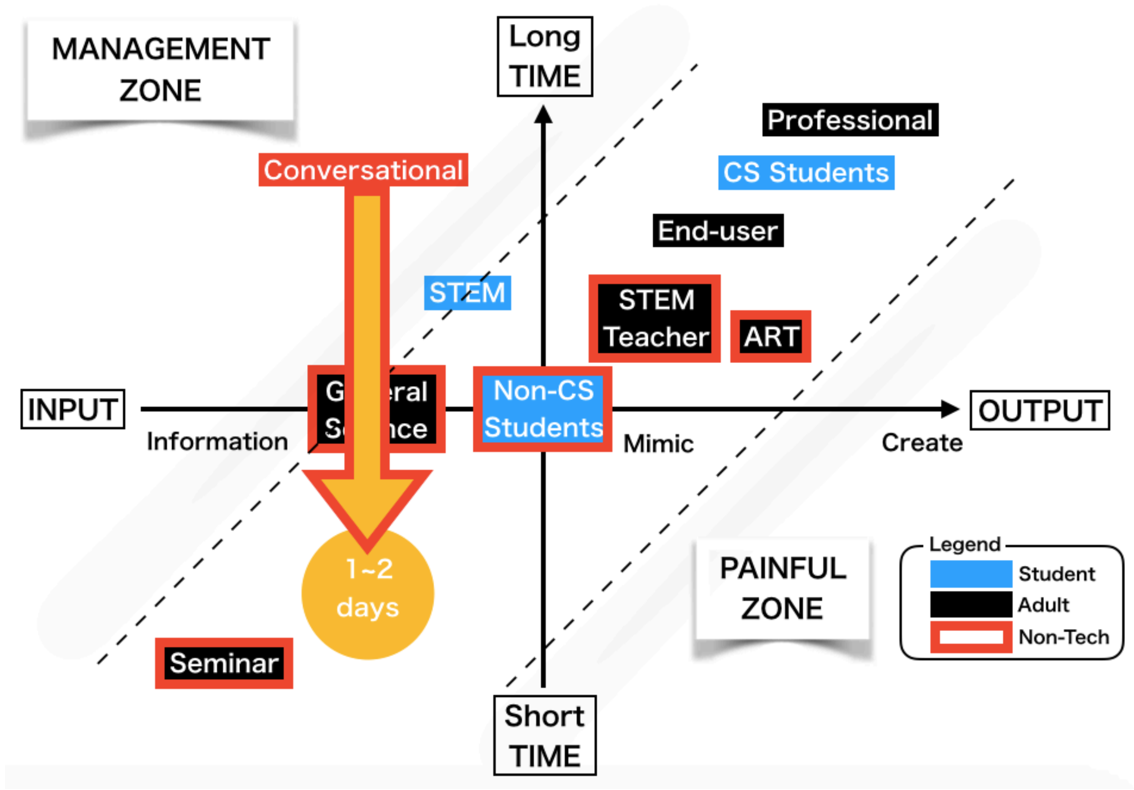

Figure 5.3. Perspective with Time axis

While conversational programmers are located in the second quadrant in Figure 5.2, they need to move to the third quadrant in Figure 5.3. This is clearly a challenge for designing learning material for people in the management zone. Also, Goal-Based Scenario (CBS) could be seen as the teaching method to support people in the fourth quadrant in Figure 5.3.

5.3 Practical Applications

When we try to design a learning material, it is important to identify the purpose and the goal of the target learners. Educational practitioners in the field can try to use the Input-Output axes that represent the proposed perspectives as the first choice to locate their students on a higher-dimensional map to separate the students from the other groups of learners because the perspectives provide them a simple dichotomy to select the type of learning stories suited for the students.

Once the type of story is selected, the practitioners can use Table 4.7 (Comparison of Type1 and Type2 from multiple viewpoints) to identify the features of a material they are going to provide and see if the features are still valid. This process is convenient and practical and should be included in the first stage of the learning material design process.

5.4 Research Limitations

This study evaluated that the story-building method from a “past to present” perspective is valid for non-technical adult learners. And the story-building method from a “present to future” perspective is valid for technical adult learners. However, we did not evaluate if the story-building method for non-technical people also works for technical people, nor if the story-building method for technical people works for non-technical people (Table 4.8). It would be worth verifying the effectiveness of the stories with the two classes of learners. In addition, investigating the influence of the instructor’s skill on learning outcomes would be useful to make the teaching materials not reliant on the instructor’s skill.

This study suggests that a story with chronologically or logically connected learning topics reduces the cognitive workload for non-technical people when they learn complex technology, but we do not know why this is so. It is an open research topic to find a hypothesis which can explain the reason why it works. We also know that it has been revealed that there are five problems with a story created from a "present to future" perspective when it is provided completely online. It is worth researching solutions to these problems by utilizing the findings in this study.

Table 4.8

Limitations of the coverage of the study

	Past to Present	**Present to Future**
Non-technical People	Validated	Not Researched Yet
Technical People	Not Researched Yet	Validated

In addition, since new technologies can change rapidly and drastically, learners would be put in a situation where they have to advance their learning in the absence of teachers. Research on how we can apply the features of story-building methods in a learning environment where learners teach each other online or offline would contribute to making the education scalable.

5.5 Future Works

There are some non-technical adult learners who fail in learning technologies with a learning material created by the proposed story-building method in this study. One hypothesis which would explain such failure is that this story-building method would not work for the learners who do not have sufficient experience that is assumed by the learning material, as depicted in Figure 5.3 (experienced area is colored in black). Qualitative research on the failed learners would help test the hypothesis.

Figure 5.4. Why some learners fail?

Figure 5.5. Outside to Inside Approach

Another practical research topic is whether the method works for a group of people who do not have any experience at all. For example, children fall into this group of learners. The steps to build a figure go from outside to inside in this case, as depicted in Figure 5.5. In this case, a dummy figure which has nothing inside would be created first and then the inside would be filled later. In the context of emerging technology, the use of high-level tools or APIs would correspond to the shape of a dummy figure. Learners would be able to learn how to use the tools quickly, but they would not understand what the tools are doing. The understating of how the tools work comes later. In the context of foreign language education, a shape of a dummy figure would correspond to grammar. The educational strategy that emphasizes grammar is not popular in schools nowadays, but it would be a good strategy for adult learners.

Online education is one of the practical methods to make education available for a large group of learners, freeing them from time and location constraints. For the learners who have time and marginal knowledge of the learning topic, online education would work well, as previous research has reported. However, the same strategy does not satisfy conversational programmers for the reasons Wang et al. (2018) found.

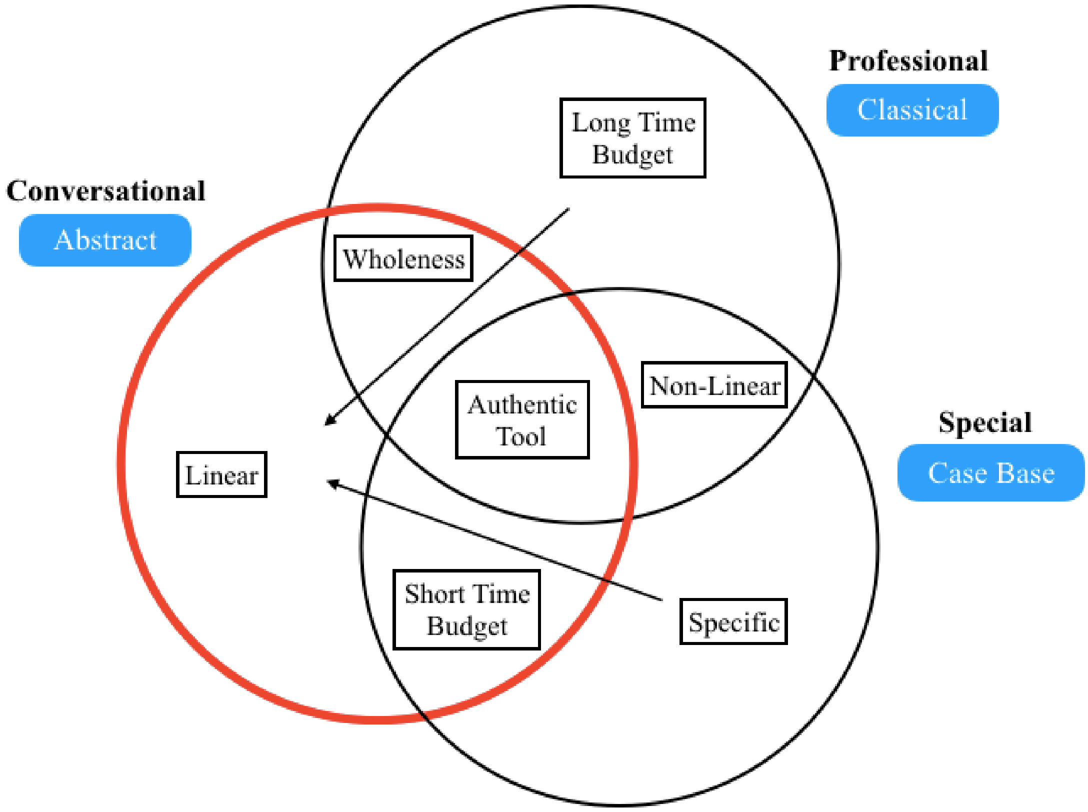

Figure 5.6. Async Online Education using the Abstracted Method

Now that we have identified issues with online education for professionals in the first quadrant in Figure 5.3 and that we know Goal-based Scenario (GBS) could cover the fourth quadrant in Figure 5.3, research for an async online educational method in the third quadrant is ready to be tackled with the knowledge depicted in Figure 5.6.

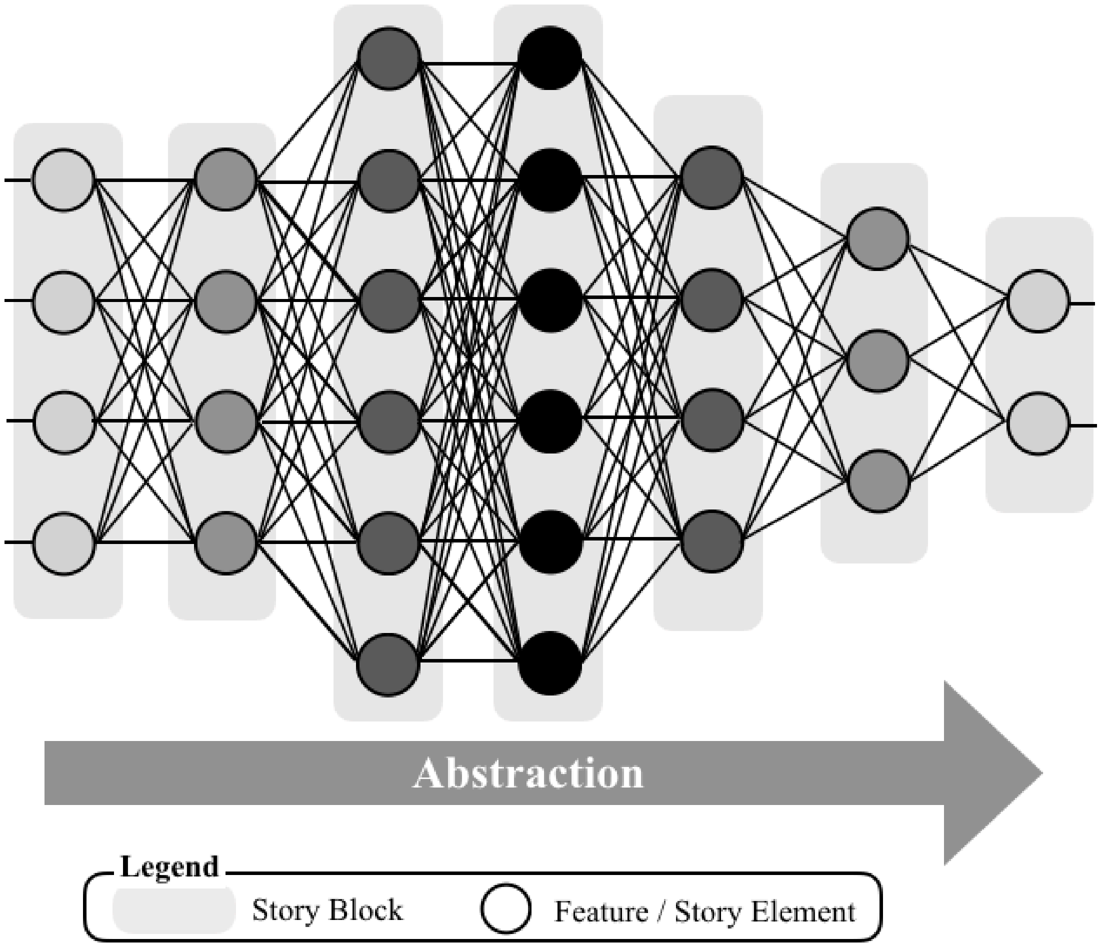

Figure 5.7. Neural Network Layers

Furthermore, it is also conceivable to explore the relationship between this research and new findings related to recent deep learning research in the area of artificial intelligence like the AI researcher, Shunk, did when he created CBR and GBS. Since each layer in a deep learning neural network is built with combined features found in a previous layer, higher layers can be considered to represent higher abstractions (Figure 5.7). Each layer seems to correspond to a story block and finding weighted connections of story elements between the two adjacent main story blocks such that a seemingly complicated relationship between the story blocks becomes practically linear would help us understand how the internal story elements should be designed.

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LIST OF PUBLICATIONS

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- Seya, Keisuke, Nobuyuki Kobayashi, et al. "Features of a Good Story for Non-technical Adults to Learn Emerging Technologies." International Journal of Emerging Technologies in Learning, vol. 15, no. 03, 2020
- Seya, Keisuke, Nobuyuki Kobayashi, et al. "Method of Creating Story-Based Lectures from a Past-to-Present Perspective That Helps Non- Technical Adult Learners Understand AI." Review of Integrative Business and Economics Research, vol. 9, no. 1, 2019, pp. 16–45.
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Conference Papers (Full Paper, Peer Reviewed)

- Seya, Keisuke, and Seiko Shirasaka. "Building Robots and Story-Based Learning to Teach Cyber-Physical Systems Effectively to Any Class of Audiences Ranging from Elementary School Students to University Graduates." INCOSE International Symposium, vol. 26, no. s1, 2016, pp. 124–36. Wiley Online Library, doi:10.1002/j.2334-5837.2016.00319.x.
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APPENDIX

RESULTS OF SURVEY COLLECTED IN COURSE I

This appendix provides the results of a survey collected in Course I. Each ID followed by a number represents a person who answered the given question.

Engineers are ID12, ID16, ID26, ID32, ID50, ID68, ID69, ID73, and ID75. ID26 has no programming experience. ID32, ID50, ID68, ID69, ID73, and ID75 are at a beginner level. ID12 and ID16 are at a senior level. Non-Enginners but who have Senior Level of programming skills are ID3, ID9, ID19, ID23, ID63, and ID85. The rest of the people are not enginners and have no programming experience or at a beginner level.

The same questions are asked before and after the lecture. A letter ‘A’ indicates that the question was asked after the lecture, and a letter ‘B’ indicates that the question was asked before the lecture.

Question 1B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Can you explain the mechanism of artificial intelligence to others?	0	-3	-1	-3	-3	1	-1	-1	0	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	-1	-3	-3	-3	2	0	0	-3	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	-3	1	-2	-3	-3	-3	-3	-3	-2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	0	-3	-2	1	-2	-3	-1	1	-3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	0	-3	-2	-1	-3	-3	-2	-3	-3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	-3	-2	-3	-3	-1	-1	0	-1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	-2	1	-2	-3	-3	-3	-3	0	-3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	-2	0	0	1	-3	-3	-2	-3	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	-3	-1	-2	0	-2	-3	-3	-3	-3

Question 2B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Can you	-1	-3	-3	-3	-3	-1	-3	-3	0	-3

program artificial intelligence alone?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-3	-1	-3	-3	-2	-2	-3	-3	-3	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	-3	1	-3	-3	-3	-3	-3	-3	-2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	-3	-3	-3	-3	-3	-3	-3	-3	-3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	-1	-3	-3	-3	-3	-3	-3	-3	-3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	-3	-3	-3	-3	-3	-1	-3	-3	-3
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	-3	1	-3	-3	-3	-3	-3	-3	-3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-3	-3	-3	-3	-3	-3	-3	-3	-3	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	-3	-3	-3	-2	-3	-3	-3	-3	-3

Question 3B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you can and will deeply understand AI in the future?	0	0	1	-3	2	2	-1	1	1	-1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	2	1	0	3	2	0	0	-2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	0	1	0	1	-1	-1	-1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	2	-3	0	1	1	-3	0	1	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	-2	-1	1	0	-3	0	-1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	-1	0	1	2	2	1	2	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	0	1	2	-3	0	-2	0	2	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	0	2	0	2	-3	0	0	-3	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-1	-1	0	2	1	0	0	-1	0

Question 4B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will be unable to keep up with classes that understand artificial	1	0	-1	-3	-2	-1	1	0	-3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	-1	-2	0	1	-2	-1	3	-1	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	0	-1	0	-1	0	-1	2	2	0

intelligence in the future?	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-2	-2	3	3	-2	-2	3	0	-1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	-1	0	1	0	1	3	0	-1	0
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	0	1	1	-1	-2	-3	0	0	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	0	0	0	3	0	3	0	-2	0
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	-3	0	-2	3	3	0	1	0
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-1	2	-1	0	-1	-1	0	-1	1	0

Question 5B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
From now on, are you confident that you will be able to better understand the content of the lessons to understand artificial intelligence?	-1	0	1	-2	2	2	-2	1	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	0	0	2	2	-3	0	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	1	0	1	0	1	0	1	-2	-2	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	2	3	-3	1	1	-2	0	2	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-2	2	-1	-1	0	0	-3	0	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	-2	0	1	2	2	1	0	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	0	0	2	-3	0	-3	1	2	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	1	3	1	2	-3	-2	0	-2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	0	1	1	2	1	0	1	-1	0

Question 6B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you will achieve good results in understanding AI?	-2	-1	1	-3	2	2	-2	0	-1	-2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	1	1	-2	-1	1	-1	-3	0	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	0	0	0	1	0	0	-2	-2	-1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	0	2	-2	-3	0	-1	-3	0	0	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	1	-2	-3	0	-1	-3	0	-3	0

	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	-1	-3	-1	-1	2	2	-1	0	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	-1	0	0	-3	-2	-3	-1	2	-2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	-2	2	0	1	-3	-3	0	-3	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-2	0	0	0	0	-3	0	-1	0

Question 7B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will not be able to understand artificial intelligence in the future?	1	-1	-1	-2	-1	-2	2	0	-3	-2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	1	2	-1	-1	-1	-1	0	0	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	0	-1	0	-1	-1	-2	2	2	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-1	0	-2	-1	-2	0	2	0	-1	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	-1	0	1	-1	0	-3	0	1	0
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	-1	0	-2	0	-2	0	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	-2	0	-2	1	1	1	-1	-1	-1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	-1	2	0	-2	3	0	0	-2	0
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-2	1	-1	0	-1	0	-1	0	0

Question 8B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will be weak at understanding artificial intelligence in the future?	1	-1	-1	1	-3	-2	0	0	-3	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	1	-3	-3	-1	-1	-3	-2	-1	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-2	-1	-1	0	-1	0	-2	1	1	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-1	0	-2	-1	-2	-2	3	0	-1	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	-2	0	-1	-1	0	0	0	1	0
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	-2	-1	0	-3	-2	-3	-1	1	-2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	-2	0	-3	1	-1	1	0	-1	-1

	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	-1	-3	0	-2	3	0	0	-1	0
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-1	-1	-1	-1	-1	-1	0	-1	-3	0

Question 9B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you understand AI well?	-1	0	1	-3	2	1	-2	1	3	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	1	2	0	1	1	0	0	0	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	1	0	-2	1	0	1	-2	-2	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	0	-2	1	2	2	-3	0	1	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	3	0	-1	0	0	-1	0	-1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	-1	0	1	2	2	0	0	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	0	0	1	-3	1	-2	0	1	-1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	0	3	0	2	-3	0	0	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-2	1	0	1	1	0	0	0	0

Question 10B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find it interesting to understand artificial intelligence?	-1	2	3	1	2	2	1	1	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	3	2	2	2	2	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	1	3	2	2	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	0	3	3	3	1	3	2	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	1	1	3	1	2	3	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	0	2	3	3	3	3	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	1	1	3	0	2	0	2	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	3	3	3	0	2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	0	2	-1	3	1	1	1	3

Question 11B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find learning about artificial intelligence fun?	-1	2	3	0	2	2	2	1	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	2	2	1	2	2	2	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	1	3	2	2	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	1	1	2	3	2	1	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	1	2	2	1	1	1	1	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-2	2	3	3	3	3	2	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	1	1	0	0	2	0	2	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	1	3	-1	3	0	1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	0	1	0	1	1	1	1	3

Question 12B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you like studying to understand artificial intelligence?	0	2	1	0	2	2	2	1	0	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	0	3	2	2	1	2	0	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	2	1	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	2	1	1	1	3	0	1	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-2	3	1	1	2	0	0	1	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-1	2	1	3	3	3	0	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	1	1	0	0	2	0	2	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	1	3	-3	3	0	0	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	0	0	0	-1	1	1	1	0	3

Question 13B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think it	-1	-2	-3	-1	-3	-2	-2	0	-3	-3

is boring to understand artificial intelligence?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	-1	-3	-3	-2	-1	-3	0	-3	-2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-2	-2	-1	-3	-1	-1	-2	-2	-2	-1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-2	-2	-1	-1	-3	-3	-2	-3	-2	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	-3	-2	-3	-1	-1	-2	-3	-1	-1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	-1	-1	-2	-3	-3	-3	-3	-2	-2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	-2	-1	-3	-3	-2	0	-2	-1	-2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-2	-3	-1	-3	-1	-3	-1	-2	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-2	-2	-1	-2	-1	-1	-3	-2	-2	-3

Question 14B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find it fun to study to understand artificial intelligence?	0	2	1	1	2	2	2	1	0	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	-1	3	2	2	-1	2	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	2	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	-3	-1	1	2	2	1	1	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	2	2	1	1	1	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-1	2	3	3	3	3	1	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	1	1	0	0	2	0	1	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	1	3	1	3	1	3	0	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	0	0	1	-1	1	1	1	1	3

Question 15B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it fun to solve problems to understand artificial intelligence?	0	1	2	0	2	2	0	1	0	-2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	1	0	0	3	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	-1	1	2	1	0	2	1	1	1

	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	1	1	2	2	0	1	1	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	1	1	1	1	0	1	0	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-3	1	1	3	3	2	0	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	1	0	-1	0	2	-1	1	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-1	1	3	0	3	0	3	0	-2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	-2	0	1	-1	1	1	0	-1	3

Question 16B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you like to understand artificial intelligence?	0	2	2	0	2	2	1	1	1	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	2	2	0	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	2	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	1	1	2	2	0	1	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	2	1	1	0	1	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-2	2	3	3	3	1	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	1	1	1	0	2	-1	1	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	0	3	1	3	0	1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	0	1	-1	1	1	1	0	3

Question 17B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it important for you to understand artificial intelligence?	1	3	2	2	2	2	3	3	3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	1	2	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	1	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	1	3	2	3	2	3	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	3	2	0	3	2	2

	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-1	2	3	2	3	2	1	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	1	1	3	1	2	1	2	1	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	2	3	3	3	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	1	3	0	2	0	1	1	3

Question 18B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How useful do you find being able to understand artificial intelligence to be in your future?	2	2	2	2	2	3	2	2	3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	-1	3	2	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	1	2	2	2	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	3	3	2	3	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	3	2	1	2	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	1	-1	2	3	3	3	2	3	3
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	2	1	3	2	1	2	2	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	3	3	3	1	2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	1	2	1	3	1	1	2	3

Question 19B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
If you don't understand artificial intelligence, do you think it won't stop in the future?	-2	2	-2	-1	-2	1	-1	0	-3	-2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	1	-3	0	-1	-1	-1	-2	-1	-1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	0	0	-3	-2	-1	-1	2	2	-2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-1	-2	-1	-2	-2	-3	-2	-3	-1	-3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	-3	-3	0	-3	0	-1	-3	-1	-2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	0	-2	-3	-2	-3	0	-3	-3
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	-1	-1	-3	-2	-2	-1	1	0	-1

	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-1	-3	-1	-3	-1	-3	-1	-1	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-2	-2	-2	-2	-3	-1	-1	-2	-3

Question 20B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is what you learn in classes to understand artificial intelligence important?	-1	2	3	2	3	2	2	2	3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	1	3	2	2	1	1	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	1	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	0	2	2	2	3	2	2	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	2	3	0	2	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	1	1	3	2	2	2	2	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	2	1	3	2	1	0	2	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	3	3	3	1	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	1	3	1	2	1	1	2	3

Question 21B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think that what you learned in the class to understand artificial intelligence will be useful for learning other subjects?	2	2	3	1	1	3	1	3	-2	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	2	2	1	1	2	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	2	1	1	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	0	1	2	2	3	3	2	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	1	1	3	1	1	0	-1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	0	-2	2	3	2	3	0	0	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	1	1	3	2	1	0	1	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	2	2	1	1	3	1	1	2	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	0	1	2	-1	3	0	1	0	3

Question 22B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How important is it that you can understand artificial intelligence better than others?	2	2	0	1	2	2	2	1	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	1	3	0	2	1	2	1	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	0	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	0	2	3	0	3	2	3	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	1	-1	3	3	0	2	0	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	-2	1	3	3	2	3	0	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	1	1	3	2	2	0	0	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	2	0	3	1	2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	1	1	2	-1	2	0	0	1	0

Question 23B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think that what you have learned to understand artificial intelligence will help you in your daily life?	2	2	2	2	1	2	1	1	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	1	0	2	3	2	1	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	1	0	0	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	0	1	2	2	3	2	0	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	0	1	3	-1	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	-1	-1	2	3	3	2	2	1	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	1	1	3	2	1	1	-1	0	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	2	1	1	1	1	3	1	2	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	-1	0	2	0	3	1	1	0	0

Question 24B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it important	2	2	1	1	1	2	2	2	3	0

for you to have a deep understanding of artificial intelligence?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	1	2	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	1	1	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	2	3	2	3	2	1	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	3	3	-1	3	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	1	-3	2	3	3	3	3	2	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	1	1	3	2	1	1	0	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	1	3	1	3	1	2	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	3	1	2	1	1	2	3

Question 25B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How important is having knowledge of artificial intelligence in your future?	3	2	2	1	2	3	2	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	-1	3	1	2	1	2	2	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	1	1	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	2	2	2	3	2	3	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	3	3	1	2	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	1	-1	2	3	3	3	3	3	3
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	3	2	1	3	2	2	1	2	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	3	1	3	1	3	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	1	2	1	2	1	1	1	3

Question 26B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you prefer a style where you listen to all the lectures and work on the hands	0	0	3	2	3	3	-2	2	3	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	2	3	2	3	1	-2	-1	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	0	3	-1	3	1	1	2

together?	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	-2	-3	0	-1	2	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	2	3	1	3	3	1	2	2	-1	-2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	-3	-1	-2	3	3	2	-1	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	-1	-3	-1	2	3	-1	3	0
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	2	-1	0	-2	3	3	-1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	0	3	0	2	3	-3	-1	3	-3

Question 27B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Would you like a class where you can practice your hands by moving your hands at the same time as the lecture?	1	1	3	2	3	-2	3	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	-2	3	1	3	3	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	3	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	3	3	2	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	2	3	3	3	3	2	2	3	3	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	2	2	3	3	3	2	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	-1	3	3	2	3	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	3	3	0	3	2	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	3	2	2	3	3	2	3	3

Question 28B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you like the style of learning artificial intelligence through history?	2	1	3	2	3	3	3	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	3	3	3	3	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	2	3	1	3	2	3	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	3	3	3	3	3	3	3

	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	2	2	3	3	3	3	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	0	3	2	3	2	0	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	2	3	3	2	0	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	3	3	2	2	1	3	2	3	3

Question 29B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you find the past people failed or troubled?	1	1	3	3	1	2	3	2	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	2	1	3	2	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	2	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	1	1	3	3	3	3	1	2	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	3	1	2	1	0	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	2	2	2	3	2	3	2	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	3	1	1	1	2	3	3	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	1	3	3	3	2	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	3	1	2	2	3	1	1	3	3

Question 30B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you know how to solve it?	1	1	3	2	2	2	2	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	3	3	1	2	3	2	2	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	2	2	-1	2	0	0	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	1	0	2	2	0	2	0	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	1	1	0	0	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	1	1	2	3	2	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	3	1	-1	1	1	1	3	2	2

	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	1	3	2	3	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	1	-1	2	1	-1	3	1

Question 31B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did it help you to understand while visually checking images such as graphs?	2	2	3	3	3	2	3	3	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	3	2	3	3	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	3	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	2	3	3	3	3	1	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	3	3	3	3	1	3	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	3	2	2	3	3	3	1	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	3	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	3	2	3	2	3	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	3	3	3	2	3	3	3	3	2

Question 32B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you understand the meaning of the feature amount that you heard from the top down in artificial intelligence?	1	1	3	1	2	1	2	3	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	3	3	2	1	1	3	-2	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	1	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	1	-2	2	2	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	2	2	1	0	1	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	1	2	1	2	3	1	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	3	1	1	2	2	0	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	2	0	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	0	1	2	3	1	1	2	1

Question 33B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
	1	1	3	1	3	1	2	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	1	1	2	-2	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	1	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	0	2	3	3	2	3	2	0
Did you know why it works for features?	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	2	3	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	2	1	3	3	2	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	2	1	2	2	1	0	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	1	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	0	1	2	2	1	1	3	2

Question 34B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
	1	1	3	1	3	1	2	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	1	3	2	-2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	2	2	2	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	1	1	2	2	1	2	2	2	0
Did you know what the features are?	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	3	2	1	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	2	1	3	3	1	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	2	1	0	2	1	0	2	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	2	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	0	1	2	2	1	1	3	1

Question 35B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you know	1	0	2	1	2	1	2	3	3	3

how features can be used?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	0	2	3	-2	3	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	1	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	1	2	3	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	2	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	0	1	1	3	3	1	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	1	1	1	0	1	0	2	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	-1	1	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	1	0	1	2	2	1	1	3	1

Question 36B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did "how you can use" and "why it help" connect features?	2	0	2	1	2	1	2	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	3	3	1	1	2	2	-1	3	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	1	2	1	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	0	2	2	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	2	1	2	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	0	2	1	2	3	1	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	1	1	1	1	1	0	2	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	1	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	0	1	2	2	1	1	3	1

Question 37B	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How much do you want to recommend this course to other friends?	7	7	8	7	10	7	10	10	8	10
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	7	10	10	6	9	9	9	5	10	10
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	10	8	6	10	8	9	9	8	8	10

(Net Promoter Score)	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	10	8	8	8	8	10	9	8	7	7
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	4	10	10	10	10	7	8	9	9	9
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	7	9	3	7	9	9	10	7	10	8
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	7	8	5	9	7	8	5	8	7	10
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	9	8	8	8	10	8	10	7	10	8
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	10	7	10	9	7	9	8	7	10	8

Question 1A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Can you explain the mechanism of artificial intelligence to others?	0	1	2	-1	2	2	1	2	3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	2	1	1	1	3	1	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	2	1	2	1	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	1	2	2	1	1	1	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	1	1	0	2	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	1	1	2	2	2	2	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	0	1	1	1	1	1	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	2	1	2	1	2	1	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	1	1	2	2	1	1	1	1

Question 2A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Can you program artificial intelligence alone?	0	-2	1	-3	0	1	-1	1	2	1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	1	1	-3	-1	1	-2	-3	2	-2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	1	1	1	0	1	-1	0	-3	-3	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-1	2	-2	-2	-1	0	-2	-3	-1	-1

	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-3	1	-1	-1	0	-1	-3	0	-2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-3	0	-2	-1	-1	2	2	-1	-1	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-3	0	1	-3	-3	-1	-3	-2	-2	-1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-2	0	0	-2	-2	-3	-1	-1	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	-3	-2	-2	-1	1	-3	-1	-1	0

Question 3A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you can and will deeply understand AI in the future?	1	0	2	0	2	2	1	3	2	1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	1	1	3	3	1	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	1	2	1	1	0	0	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	1	1	2	3	2	1	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	1	2	0	-1	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	2	-1	1	1	3	3	1	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	0	2	0	1	0	1	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	1	3	1	1	2	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	1	1	1	2	-1	1	0	2

Question 4A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will be unable to keep up with classes that understand artificial intelligence in the future?	0	1	-2	0	-2	-2	0	0	-3	-1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	-1	-2	-1	-1	-3	0	2	-2	-2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-1	1	-1	0	-2	-1	-2	-1	-1	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	0	0	0	-2	-2	-1	0	-1	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	2	-3	-2	-1	-1	0	-1	-2	-1	-1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-2	-1	2	-1	-1	-1	-3	-1	-2	0

	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	-1	-1	-2	-1	-1	1	-1	-2	-2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	0	-3	-1	-3	-1	-2	-1	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-2	-1	-1	-2	-1	-3	0	-1	-1	-2

Question 5A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
From now on, are you confident that you will be able to better understand the content of the lessons to understand artificial intelligence?	-1	-1	2	0	3	2	1	2	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	1	3	0	0	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	0	2	1	2	1	1	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	-1	1	3	2	2	0	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	1	1	1	1	1	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	-2	1	3	1	3	2	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	1	1	1	1	-2	1	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	0	3	1	2	1	1	1	-1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	1	1	3	0	1	2	2

Question 6A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you will achieve good results in understanding AI?	0	-1	2	-2	2	2	0	1	3	1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	1	3	-1	0	3	-1	0	0	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	1	1	0	2	0	1	0	0	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	-1	0	1	2	1	0	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	3	1	1	0	-1	0	1	-2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	-1	-2	0	2	1	3	2	0	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	1	1	0	0	0	-2	-1	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	0	3	1	2	0	-2	1	-1	1

	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	-2	1	1	0	2	-1	0	0	1

Question 7A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will not be able to understand artificial intelligence in the future?	1	0	-2	-1	-3	-3	-1	0	-3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	-1	-3	0	-2	-3	-2	0	0	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	-1	-1	0	-2	-1	-3	-1	-1	-1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	-3	-1	-3	-2	-3	-1	0	-1	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	-3	-2	1	-1	-1	-2	0	-2	-1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-2	0	-1	-1	-3	-2	-3	-2	0	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	-1	-1	-3	-1	1	0	-2	-3	-3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-1	-3	-1	-2	-1	-3	-1	-1	-2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-2	-2	-1	-2	-1	-3	0	-2	-1	-2

Question 8A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think you will be weak at understanding artificial intelligence in the future?	0	0	-3	-1	-3	-2	-1	0	-2	-2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	1	-3	-2	-2	-3	-1	-1	0	-2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	-2	-1	-1	-2	-1	-2	-1	-1	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	-3	-1	-3	-2	-3	-2	-1	-2	-1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	-3	-2	-2	-1	-1	-2	-1	-2	-1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-2	-1	-1	-1	-3	-2	-3	-2	-1	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-1	-2	-1	-3	-1	-1	0	-1	-3	-2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-1	-3	-1	-3	-1	-3	-1	-1	-2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-2	-2	-1	-1	-1	-3	-1	-2	-1	-2

Question 9A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Are you confident that you understand AI well?	0	0	2	0	2	2	1	2	2	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	-2	1	3	0	1	1	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	1	1	2	2	0	1	1	1	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	0	3	2	2	1	0	2	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	3	2	1	2	0	0	1	1	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	-1	1	2	1	3	1	2	0
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	1	2	0	1	0	1	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	0	3	1	2	1	2	1	1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	1	1	1	2	0	1	0	1

Question 10A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find it interesting to understand artificial intelligence?	1	2	3	1	3	3	-1	3	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	1	3	2	2	2	2	2	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	1	3	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	2	3	2	3	2	2	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	2	2	2	2	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	3	0	3	3	3	3	2	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	3	1	3	1	2	0	2	3	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	1	3	3	3	1	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	1	1	2	1	3	2	1	2	3

Question 11A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find learning about	1	2	3	1	3	3	3	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20

artificial intelligence fun?	1	1	3	2	2	2	2	1	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	0	3	2	2	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	2	3	1	1	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	2	2	1	1	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	0	2	3	3	3	1	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	1	3	1	2	0	2	3	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	1	3	2	3	1	-1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	2	1	3	2	1	2	3

Question 12A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you like studying to understand artificial intelligence?	1	2	3	0	2	2	3	2	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	2	2	2	3	1	1	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	1	3	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	2	3	1	1	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	1	2	1	1	1	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	-1	2	3	3	3	0	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	2	1	2	1	2	0	2	3	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	0	3	1	3	-1	-1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	0	1	2	0	2	0	0	2	2

Question 13A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think it is boring to understand artificial intelligence?	-1	-2	-3	-1	-3	-2	-2	0	-3	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	-1	-3	-2	-2	-3	-3	-1	-2	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	-2	-1	-3	-2	-1	-3	-2	-2	-1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40

	-2	-3	-3	-3	-2	-3	-2	-3	-2	-2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	-3	-3	-2	-1	-3	-3	-2	-3	-3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-2	-2	-1	-2	-3	-3	-3	-3	-3	-2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-1	-3	-1	-3	-1	-2	0	-3	-2	-3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-2	-2	-3	-2	-3	-3	-3	-1	-1	-2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	-2	-1	-3	0	-3	-2	-2	-2	-3

Question 14A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you find it fun to study to understand artificial intelligence?	1	2	3	0	3	2	-1	2	1	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	2	2	3	1	1	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	1	3	2	2	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	2	3	2	1	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	1	2	2	1	1	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	3	0	2	3	3	3	1	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-1	2	1	2	1	2	0	2	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	1	3	1	3	1	-1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	1	2	0	3	1	1	2	2

Question 15A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it fun to solve problems to understand artificial intelligence?	0	1	3	0	3	2	1	2	1	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	2	2	3	2	2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	1	2	0	2	2	2	0
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	1	2	2	3	1	1	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	2	2	2	1	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60

	1	2	-2	2	2	3	3	0	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-1	2	0	3	1	2	0	1	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	2	3	1	3	1	-1	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	1	1	-1	3	1	0	2	2

Question 16A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you like to understand artificial intelligence?	1	1	3	0	3	2	2	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	1	3	1	2	3	2	1	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	2	2	1	3	2	2	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	2	3	2	1	2	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	3	1	2	2	1	2	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	2	0	2	3	3	3	1	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	1	2	1	2	0	1	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	3	1	3	-1	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	1	2	1	3	1	1	2	2

Question 17A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it important for you to understand artificial intelligence?	2	2	3	1	1	3	2	3	2	1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	3	3	1	2	2	3	2	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	2	3	3	3	2	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	2	3	1	3	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	0	2	3	3	3	3	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	2	1	3	2	2	1	2	3	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80

	3	1	3	2	3	2	3	2	3	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	2	2	3	1	3	1	2	3	3

Question 18A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How useful do you find being able to understand artificial intelligence to be in your future?	2	1	2	1	2	2	3	3	2	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	3	3	1	2	3	2	0	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	2	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	2	3	3	3	3	3	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	3	2	2	3	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	1	2	3	3	3	3	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	2	1	3	2	2	2	3	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	3	1	3	1	3	2	3	2	3	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	3	2	3	1	3	1	2	2	3

Question 19A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
If you don't understand artificial intelligence, do you think it won't stop in the future?	-1	1	-2	-2	-2	-1	-2	0	-2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-1	-1	-3	1	-1	-3	-2	0	0	-3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	-3	-1	1	-3	-2	-2	-3	0	0	-2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	-3	-2	-3	-2	-3	-3	-3	-2	-2	-3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	-1	-3	-3	-3	-1	-2	-1	-3	-3	-2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	-2	0	-1	-2	-3	-3	-3	-1	-1	-2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	-2	-1	-3	-1	0	-2	1	-1	-3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	-3	-1	-3	-2	-3	-3	-3	-2	-2	-2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	-2	-2	-3	-1	-3	0	-2	-2	-3

Question 20A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is what you learn in classes to understand artificial intelligence important?	1	1	3	2	2	3	2	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	3	3	1	2	3	2	2	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	1	2	3	3	2	1	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	3	2	1	1	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	0	1	2	3	3	3	2	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	2	3	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	3	2	3	2	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	1	1	3	1	3	1	2	2	3

Question 21A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think that what you learned in the class to understand artificial intelligence will be useful for learning other subjects?	1	1	2	0	0	1	1	3	2	0
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	-2	3	2	1	1	-1	2	1	1	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	2	1	3	0	2	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	1	1	1	3	3	2	0	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	3	3	2	2	3	0	1	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	3	2	0	2	3	2	3	1	0	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	1	3	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	2	3	1	1	1	3	2	3	1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	1	3	1	2	1	2	2	3

Question 22A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How important	2	1	2	1	1	2	2	2	2	-2

is it that you can understand artificial intelligence better than others?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	1	3	0	1	2	1	0	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	2	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	3	3	3	1	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	2	3	1	1	1	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	0	1	2	3	3	3	2	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	2	2	2	1	2	3	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	2	1	3	1	3	2	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	3	1	2	1	1	2	2

Question 23A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you think that what you have learned to understand artificial intelligence will help you in your daily life?	2	1	2	1	0	1	2	3	2	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	2	3	1	1	3	1	0	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	2	1	1	3	1	2	1	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	2	2	2	3	1	1	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	1	2	3	0	1	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	1	2	3	3	3	0	0	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	2	2	2	1	0	1	1
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	1	0	2	2	3	2	1	-1
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	0	0	2	0	3	1	1	2	1

Question 24A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Is it important for you to have a deep understanding of artificial intelligence?	2	1	2	1	1	2	1	3	2	1
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	2	3	1	1	3	1	1	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	3	2	2	3	1	1	2

	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	3	3	3	3	3	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	3	3	1	2	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	0	2	3	3	3	3	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	1	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	1	1	3	1	3	3	3	1	3	0
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	3	1	3	1	1	2	2

Question 25A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How important is having knowledge of artificial intelligence in your future?	2	1	2	1	1	2	2	3	3	2
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	2	3	0	2	2	2	0	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	3	2	2	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	2	2	3	3	3	2	2	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	2	3	3	1	3	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	0	2	3	3	3	3	2	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	1	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	1	3	1	3	2	3	2	3	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	2	3	1	3	1	1	2	2

Question 26A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Do you prefer a style where you listen to all the lectures and work on the hands together?	0	0	3	2	3	3	-2	2	3	-3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	3	2	3	2	3	1	-2	-1	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	0	3	-1	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	-2	-3	0	-1	2	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	2	3	1	3	3	1	2	2	-1	-2

	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	-3	-1	-2	3	3	2	-1	-1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	-1	-3	-1	2	3	-1	3	0
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	0	2	-1	0	-2	3	3	-1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	-3	0	3	0	2	3	-3	-1	3	-3

Question 27A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Would you like a class where you can practice your hands by moving your hands at the same time as the lecture?	1	1	3	2	3	-2	3	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	-2	3	1	3	3	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	3	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	2	2	3	3	3	2	2	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	2	3	3	3	3	2	2	3	3	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	3	2	2	3	3	3	2	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	-1	3	3	2	3	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	3	3	0	3	2	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	2	3	2	2	3	3	2	3	3

Question 28A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you like the style of learning artificial intelligence through history?	2	1	3	2	3	3	3	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	3	3	3	3	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	3	2	3	1	3	2	3	1	2
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	3	3	3	3	3	3	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	2	1	2	2	3	3	3	3	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	0	3	2	3	2	0	3

	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	2	3	3	2	0	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	3	3	2	2	1	3	2	3	3

Question 29A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you find the past people failed or troubled?	1	1	3	3	1	2	3	2	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	2	1	3	2	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	2	2	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	1	1	3	3	3	3	1	2	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	3	1	2	1	0	3	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	2	2	2	3	2	3	2	3	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	2	3	1	1	1	2	3	3	1	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	1	3	3	3	2	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	3	1	2	2	3	1	1	3	3

Question 30A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you know how to solve it?	1	1	3	2	2	2	2	2	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	3	3	1	2	3	2	2	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	2	2	-1	2	0	0	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	1	1	0	2	2	0	2	0	1	1
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	2	2	1	1	0	0	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	1	1	2	3	2	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	3	1	-1	1	1	1	3	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	1	3	2	3	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	2	1	1	1	-1	2	1	-1	3	1

Question 31A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did it help you to understand while visually checking images such as graphs?	2	2	3	3	3	2	3	3	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	3	3	2	3	3	3	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	3	3	2	3	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	2	3	3	3	3	1	2	3
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	1	3	3	3	3	3	3	1	3	3
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	3	2	2	3	3	3	1	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	1	3	1	3	2	2	3	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	2	3	2	3	2	3	2	3	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	3	3	3	3	2	3	3	3	3	2

Question 32A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you understand the meaning of the feature amount that you heard from the top down in artificial intelligence?	1	1	3	1	2	1	2	3	3	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	1	3	3	2	1	1	3	-2	2	3
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	3	1	1	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	3	1	-2	2	2	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	2	2	1	0	1	2	1
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	1	2	1	2	3	1	3	2
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	-2	3	1	1	2	2	0	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	2	0	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	0	1	2	3	1	1	2	1

Question 33A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did you know	1	1	3	1	3	1	2	3	2	3

why it works for features?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	1	1	2	-2	3	2
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	1	2	1	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	0	2	3	3	2	3	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	2	3	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	2	1	3	3	2	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	2	1	2	2	1	0	2	2	3
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	1	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	2	0	1	2	2	1	1	3	2

Question 34A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
	1	1	3	1	3	1	2	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	1	3	2	-2	3	1
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	2	1	2	2	2	2	1	1	1
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	1	1	2	2	1	2	2	2	0
Did you know what the features are?	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	3	2	1	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	1	2	1	3	3	1	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	2	1	0	2	1	0	2	2	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	2	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	0	1	2	2	1	1	3	1

Question 35A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
	1	0	2	1	2	1	2	3	3	3
Did you know how features can be used?	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	2	3	3	1	0	2	3	-2	3	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	1	2	1	2	1	1	1

	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	3	1	2	3	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	1	1	2	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	0	1	0	1	1	3	3	1	2	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	1	1	1	0	1	0	2	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	-1	1	1	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	0	1	0	1	2	2	1	1	3	1

Question 36A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
Did "how you can use" and "why it help" connect features?	2	0	2	1	2	1	2	3	2	3
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	0	3	3	1	1	2	2	-1	3	0
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	3	1	1	1	2	1	2	1	1	2
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	2	2	0	2	2	3	2	2	2	0
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	0	2	1	2	2	2	0	1	2	2
	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	1	1	0	2	1	2	3	1	1	1
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	0	1	1	1	1	1	0	2	3	2
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	2	0	3	2	2	1	1	1	2	2
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	1	1	0	1	2	2	1	1	3	1

Question 37A	ID1	ID2	ID3	ID4	ID5	ID6	ID7	ID8	ID9	ID10
How much do you want to recommend this course to other friends? (Net Promoter Score)	7	7	8	7	10	7	10	10	8	10
	ID11	ID12	ID13	ID14	ID15	ID16	ID17	ID18	ID19	ID20
	7	10	10	6	9	9	9	5	10	10
	ID21	ID22	ID23	ID24	ID25	ID26	ID27	ID28	ID29	ID30
	10	8	6	10	8	9	9	8	8	10
	ID31	ID32	ID33	ID34	ID35	ID36	ID37	ID38	ID39	ID40
	10	8	8	8	8	10	9	8	7	7
	ID41	ID42	ID43	ID44	ID45	ID46	ID47	ID48	ID49	ID50
	4	10	10	10	10	7	8	9	9	9

	ID51	ID52	ID53	ID54	ID55	ID56	ID57	ID58	ID59	ID60
	7	9	3	7	9	9	10	7	10	8
	ID61	ID62	ID63	ID64	ID65	ID66	ID67	ID68	ID69	ID70
	7	8	5	9	7	8	5	8	7	10
	ID71	ID72	ID73	ID74	ID75	ID76	ID77	ID78	ID79	ID80
	9	8	8	8	10	8	10	7	10	8
	ID81	ID82	ID83	ID84	ID85	ID86	ID87	ID88	ID89	ID90
	10	7	10	9	7	9	8	7	10	8