Study about the Aptitude-Treatment Interaction between Learning Using the e-Learning System and Learning Type of Learner

Ryo Sugawara, Shun Okuhara, and Yoshikazu Sato

***Abstract*—The low completion rate of e-learning, which has been considered as a problem since its inception, is recently attracting renewed attention as a problem yet to be solved. This study confirms the assumption that the effect of e-learning varies with the learner's learning type, and that a low e-learning completion rate results from the participation of learners who are unsuited to e-learning. It has been found that the differences between e-learning achievement rates can be classified into seven learning types. This suggests that e-learning may have little effect when the e-learning system does not match the learner's learning type.**

***Index Terms*—e-Learning, act of learning, learning type, aptitude-treatment interaction.**

I. Introduction

It is generally said that e-learning began in Japan in the year 2000 [1]. This means that, as of 2017, 17 years have passed since the start of the full-scale development, introduction and operation of e-learning systems in Japan. As indicated by the term "Internet revolution in education" [2], in 2000 there were great expectations for e-learning. However, five years later in 2005, an early review noted that e-learning was not sufficiently widespread to have reached the practical stage [3]. This was true even for higher education, where e-learning had been expected to proliferate the most compared with other forms of education including school education, social education, and in-house education. This was also a marked trend in the United States, which leads the world in terms of the promotion of e-learning, as noted in the following statement: The great excitement of e-learning in the 1990s has given way to a "pervading sense of disappointment" [4]. Many researchers have pointed out various issues related to this trend. For example, Clark and Mayer [5], on the basis of their empirical studies on learning using multimedia, argue that much of what is today called e-learning is simply computer-based training (CBT), which has been available for 30 years, in the sense that it simply digitizes paper-based educational materials (books, etc.) and reproduces them on computer networks. An explanation for this is that in the early days there was con-fusion about what and how to learn using e-learning, which was a new learning tool, and the information and communication technology (ICT) infrastructure was not sufficiently well developed to fully exploit the benefits of e-learning.

The development and proliferation of e-learning were boosted by the need to reduce various in-house education costs: e.g., the cost of time spent by in-house learners, the cost involved in transporting learners from remote locations for classroom education and the cost of planning and conducting group training. Unlike correspondence education, education using broadcasting media, and education using multimedia, e-learning can be engaged in at a time and place convenient for each learner and allows bidirectional real-time communication between learners and teachers. This solves major problems with distance education by reducing the time required for delivering and submitting assignments and exchanging questions and answers and thereby overcoming the physical distance involved when students are remotely located. The transition from the use of printed materials in correspondence education and distance education using broadcasting media or of large capacity media in multimedia education to a range of learning content distributed through communication lines has allowed us to solve a number of problems that could not be overcome by conventional distance education and has provided the following capabilities:

1) It is possible to expand the choice of learning materials (expanded choice of learning materials).

2) It is possible to choose various forms of learning such as individual learning, classroom learning, and blended learning combining the former two (expanded choice of learning methods) [6].

3) It is possible to distribute learning materials, submit assignments, and return evaluation results instantly over the network (reduced temporal distance).

4) When questions arise during learning, students can use email or other tools to obtain prompt answers (improved efficiency in learning).

5) Rather than one-to-one unidirectional communication between a learner and a teacher, it is possible to conduct prompt bi-directional communication over the network, including communication between students and one-to-many communication (capability of bidirectional and one-to-many communication).

6) It is possible to give an assignment instantly according to the learner's state of learning (profile) and evaluate the result over the computer network [6]; this has been impossible in classroom education or conventional distance education because it requires a complicated calculation. As a

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result, it has become possible to overcome many problems in distance education that could not be solved without the use of a well-developed ICT environment [7].

On the other hand, e-learning systems that have been developed and deployed for in-house education may not be easily applied to school education without modification. Whereas the main purpose of in-house education is to maximize corporate profits, that of school education is to provide order-made education according to the goals of each student; these types of education have different purposes in principle.

Recently, e-learning aimed at helping students pass certification examinations is be-coming popular not only in in-house education but also in school education (such as preparation for national examinations at medical universities and for language examinations). Nevertheless, e-learning in school education has been popularized by being used when teachers instruct learners to remember particular things.

However, it is important that future e-learning systems in school education be more flexible in accordance with the outline presented in the 2012 report of the Central Council for Education of the Ministry of Education, Culture, Sports, Science and Technology [8]. The report notes the importance of "a shift from conventional education centered on the transfer and injection of knowledge to active learning in which teachers and students communicate with each other, work hard together, and create opportunities for intellectual growth while stimulating each other, so that students can proactively find problems and solutions." It is expected that the use of e-learning in school education will change to include various forms such as learning management systems (LMSs), social media, social network systems (SNSs), and new media and systems that may emerge with future innovations.

This paper begins by summarizing the qualitative change and expansion in learning achieved by introducing instructional design, which is a learning theory that formed a basis for e-learning during its emergence in around 2000; by removing limitations caused by under developed ICT infrastructures; and by conducting e-learning in a well-developed ICT environment. The paper then examines the relationship between learning effects and learning types using a case of e-learning in recent university education in which the author was involved. There is a problem that many of those engaged in e-learning fail to complete the course as they find it difficult to study in a self-disciplined way. In such a case, there may be a mismatch between the e-learning system and the learning type of the learner, and this paper focuses on aptitude treatment interaction [Note 1]. Using the concept of aptitude-treatment interaction as a basis, the paper discusses the possibility that there are certain learning types suited to e-learning.

II. Development of e-Learning Theories

E-learning emerged after a long era of postal correspondence education and distance education using learning materials designed for multimedia communication [9]. E-learning is reputedly more progressive than correspondence education and distance education, as it enables teachers and students who are distant from each other geographically and temporally to communicate bidirectionally in real time over computer networks and thereby solves problems that could not be overcome with conventional distance education [7].

During its emergence, e-learning was sup-ported theoretically by the system approach proposed by Gagné[10], [11]. The system approach was emphasized during the emergence of e-learning. This was because, when de-signing a teaching cycle (including the de-termination of final goals by teachers, the development of lesson objectives and lesson plans, the development of teaching materials, and evaluation), a set of instructional design methods based on the system approach concept is highly compatible with the design of a computer algorithm when trying to achieve substantial performance in an underdeveloped ICT environment. A learning method similar to Gagné's system approach is the mastery learning process [12], [13] proposed by Bloom [14], [15].

The subsequent rapid development of ICT led to the proposal of various instructional designs (Sugawara, 2005). The learning theories forming the basis of such instructional designs can be broadly divided into objectivist and constructivist theories. The former can be further divided into behaviorist and cognitivist theories. The objectivist learning theory emphasizes instruction, where teachers pre-determine objectives according to each student's level and analyze and structurize instructions with a focus on the efficient transfer of knowledge and skill from teachers to students; whereas the constructivist learning theory emphasizes the act of learning and focuses on social situations surrounding learners, motivation related to everyday life, and learning through real experiences such as interaction with others [16].

Objectivism and constructivism are treated as contrasting concepts in four philosophic questions that form the basis of corresponding paradigms: (1) What is the act of knowing and what is truth? (ontological question); (2) What is the relationship between the knower and the object to be known? (epistemological question); (3) What are the ways of finding out knowledge? (methodological question); and (4) What characteristics do humans have? (anthropological question) [17]-[19]. Knowledge is provided by a teacher in objectivism, and knowledge is formed in the mind of each learner in constructivism [20]. Suzuki [21] explains the relationship between behaviorism, cognitivism, and constructivism using the concept of "territory" on a graph consisting of two axes: the complexity of assignment and the learner's level of proficiency (Fig. 1).

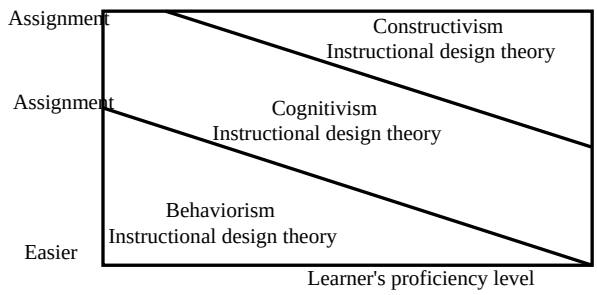

Fig. 1. Learner's proficiency level.

According to Suzuki [22], the mechanism of behavioral psychology consists of stimulation, response, and strengthening. By providing a certain stimulus in a learning process, a response to the stimulus is generated and learning is strengthened. This procedure is repeated until the goal of the learning in-tended by the teacher is achieved.

The mechanism of programmed learning developed by Skinner [23] based on the study of operant conditioning using a Skinner box, as well as various experiments such as PLATO at the University of Illinois and TICCIT at Brigham Young University [24], [25] in relation to computer-assisted instruction (CAI) carried out in the 1950s and 1960s in the United States before the development of e-learning, provided important theoretical frameworks for the subsequent development of CAI.

Gagné's nine events of instruction [26] are well known as a typical instruction model based on cognitivism. The ARCS (attention, relevance, confidence, and satisfaction) model of Keller and Suzuki [27], which emphasizes the process of providing motivation for learning, is a well-known approach based on cognitivism.

The learning models based on objectivism (behaviorism and cognitivism) that have been discussed so far are information processing models in which the learner's learning process is regarded as an information processing system that forms a connection or a group according to a certain relationship. This relationship consists of processing certain information input by the learner in the learning process and outputting the processing result. In this study, therefore the fundamental idea of objectivism is interpreted as a sequence that consists of making the following efforts. To improve the learning (output) result produced by learners, the adequacy of instruction strategies (inputs such as guiding strategies) [28] is discussed in terms of schemes of components and procedures regarding the learning environment to be developed and the action to be taken to achieve the goal of instruction. Then, detailed elements that may constitute an instruction strategy are combined in various ways to find and construct a better instruction strategy.

The conversion to active learning promoted by the Ministry of Education, Culture, Sports, Science and Technology [8] is intimately linked with constructivist learning theories. For example, Piaget proposed a framework of genetic epistemology [29], [30]. According to Piaget, humans acquire information from the outside world through the functions of assimilation and adjustment. Only the information that a cognitive structure can process at a given time is taken in by assimilation, and any cognitive structure that fails to process information well is modified through adjustment. Piaget perceived the individual learning action of the learner as a process of forming a mass of knowledge called a "schema."

Vygotsky [31], [32] presented the concept of a "zone of proximal development" and proposed social constructivism, arguing that human cognitive functions develop through social and cultural interactions. According to his theory, the level of child development is either in the zone where the learner can solve a problem unaided or in the zone of proximal development where the learner can solve a problem with guidance from an adult or a group of people. And by allowing an adult or a third person to be involved in the zone of proximal development, children can achieve cognitive development without waiting for individual maturity. In both Piaget's genetic epistemology and Vygotsky's zone of proximal development, the acquisition of knowledge is viewed as a process whereby each learner forms a knowledge system.

Since the introduction of e-learning in Ja-pan, most of its supporting theories have been objectivist learning theories. According to Mayer, the three styles of e-learning that are potentially the most effective are (1) exercises with automatic and matching feedback, (2) the fusion of independent study and cooperative learning, and (3) the use of simulation to improve proficiency [5].

As regards exercises with automatic and matching feedback, there are already many examples of their application to computer-based training or computer-based testing (CBT). As regards the fusion of independent study and cooperative learning, various forms of learning systems have been proposed. Oliver and Herrington [33] note that learning theories in education using ICT are more or less based on the principles of constructivism.

III. Aptitude-Treatment Interaction between e-Learning and Learner's Learning Type

Since the early days of e-learning, the low completion rate has been considered a significant problem. As pointed out by the e-Learning Consortium Japan [34], "With asynchronous learning, there are cases where learning is not completed within the designated period or not performed at all if the pace of learning is left to the learner's discretion. To reduce the occurrence of incompletion and increase the completion rate, it is important for supervisors to encourage learners exhibiting slow progress to proceed with learning." It also states as follows: "Some of the LMSs have a function that automatically sends emails to encourage learners exhibiting slow progress to take lessons". There are also some ASPs whose mentors monitor learners and give appropriate advice or send encouraging emails to learners exhibiting slow progress. The fact that the completion rate is increased by making such efforts has also been confirmed by the author and colleagues who have introduced e-learning in pre-enrollment education applied to those who passed the admissions office examination and the examination for selected candidates [35], [36]. Nevertheless, in principle learning must take place spontaneously. E-learning has yet to overcome this problem. In this study it is assumed that e-learning fails to ensure spontaneous learning not because of defects in the e-learning systems themselves but because of a mismatch between the learning method indicated by the e-learning content and the learner's type of learning (aptitude-treatment interaction), and this mismatch causes learners to drop out or show little progress. As stated earlier, the development of the e-learning content is often based on cognitivism, and the learning method is generally presented in the form of a manual providing study or usage instructions. In other words, it is assumed that there is an interaction between the learner's aptitude (learning type) and the

treatment (instruction method: e-learning), the effect of learning depends on their combination, and learners whose aptitude does not match the treatment are not suited to e-learning [1].

A web-based placement test was conducted to assign different difficulty levels of e-learning to students in pre-enrollment education at the university where the author works. The following case study focuses on the learning types of students who scored high in the test.

Sugawara [37] and Sugawara *et al*. [38] classified the learning types of students engaged in e-learning into seven types according to the number of logins to the e-learning system (Table I) and investigated the relationship between test score and learning type.

TABLE I: CLASSIFICATION OF LEARNING TYPES

Learning type	E-learning completion rate	No. of logins (Trf)
Long-term, complete (LTrf)	100.0(%)	≥30
Mid-term, complete (MTrf)	100.0	<30
Short-term, complete (STrf)	<100.0	10≤Trf for both first and last half
Concentrated in first half (FHaf)	<100.0	10≤Trf for first half, Trf<10 for last half
Concentrated in last half (LHaf)	<100.0	Trf<10 for first half, 10≤Trf for last half
Non-habitual (N)	<100.0	Trf<10 for first half, Trf <10 for last half
No study (NS)	No logins	

* Learning period: 3 months

The results of the investigation show that the e-learning progress rate (indicating whether the leaner has finished the e-learning assignments) differs depending on the learning type. While the progress rate was 100.0% for both the long-term and mid-term completion types, the progress rate was 21.6 points lower for the short-term incompletion type compared with the former two types. The progress rate was even lower for learners whose number of logins was concentrated in the first half of the learning period and who failed to complete the assignments (38.0 points lower), and for the learners whose number of logins was concentrated in the last half of the learning period and who failed to complete the assignments (28.7 points lower) (Table II).

TABLE II: E-LEARNING PROGRESS RATE FOR DIFFERENT LEARNING TYPES

Learning type	Task progress rate
LTrf	100.0(%)
MTrf	100.0
STrf	78.4
FHaf	62.0
LHaf	71.7
N	33.7
NS	—
Total	75.6

As regards the relationship between the test score and the learning type, learners with high scores (≥90 for Japanese and ≥90 for English) were mostly classified as either the long-term or mid-term completion type (77.8% and 88.2% for Japanese and English, respectively). In learners with lower scores (<90, ≥80 for Japanese and <90, ≥65 for English), the percentages of long-term and mid-term completion types were 13.0 points lower (64.8%) for Japanese and 24.6 points lower (63.6%) for English. The analytical results indicate that the test score is positively correlated with the habit of constant learning during the entire e-learning period (Table III).

TABLE III: RELATIONSHIP BETWEEN LEARNING TYPES AND PLACEMENT TEST SCORES

		Placement test score			
		Japanese		English	
Learning type	Achievement rate	≥90	<90, ≥80	≥90	<90, ≥65
		N: 27	N: 37	N: 17	N: 33
LTrf	100.0(%)	10	17	9	15
MTrf	100.0	11	7	6	6
STrf	<100.0	2	3	—	3
FHaf	<100.0	3	—	1	—
LHaf	<100.0	1	6	1	4
N	<100.0	—	3	—	5
NS	<100.0	—	1	—	—

IV. DISCUSSION

In response to the paper published by Sugawara and Muraki entitled "Why Cannot e-Learning Satisfy an Act to Learn?" [39], this study has discussed how e-learning has evolved since its full-scale introduction in Japan in 2000, in relation to the ICT environment in e-learning as of 2017, education and learning theory, etc. .

The low completion rate of e-learning, which has been considered a significant problem since the early days, has recently been attracting renewed attention as a problem yet to be solved (e-Learning Consortium Japan, 2017). Various measures have been adopted to address this problem, such as the development of e-learning systems that are learner-friendly; using LMSs and other tools to send emails encouraging learners exhibiting slow progress to take lessons; and arranging mentors to monitor learners and give appropriate advice or send encouraging emails to learners exhibiting slow progress.

Meanwhile, in this work, the reason for the low completion rate of e-learning was assumed and confirmed as follows. As there is an interaction between the learner's learning type and the e-learning treatment, and learning effects differ depending on the combination of both, learners with learning types that do not match the e-learning treatment are not suited to learning using e-learning systems developed by the system approach concept.

This study found that the achievement rate of e-learning (indicating whether the learner has finished the e-learning assignments) depended greatly on the learner's learning type. It is suggested that learners whose learning type does not match the e-learning treatment (a discrepancy in the aptitude-treatment interaction) may not be suited to e-learning.

APPENDIX

[Note 1] The aptitude-treatment interaction, which is a concept used by American educational psychologist Cronbach, forms a theoretical background emphasizing one-on-one instruction. The aptitude of a learner consists of

characteristics including the individual's academic ability, knowledge, personality, attitude, interest, and learning style. Treatment indicates the conditions of an instruction method including instruction techniques, assignments, involvement, curricula, and learning environments.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Ryo Sugawara conducted the research and wrote the paper; Shun Okuhara analyzed the data; Yoshikazu Sato analyzed the data; all authors had approved the final version.

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