# EFFECTIVENESS OF E-LEARNING DESIGN AND AFFECTING VARIABLES IN THAI PUBLIC SCHOOLS

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## ABSTRACT

**Purpose** –This study proposed and examined the effectiveness of e-learning content design by considering two different subjects (mathematics and reading) and areas (metropolitan and rural). This study also investigated several variables, i.e., students' satisfaction, motivation, and experience, that influenced learning abilities. Moreover, we suggest ways of improving the effectiveness of e-learning for different kinds of students, subjects, and areas.

**Methodology** – The participants were recruited from 263 randomly selected students in secondary-school grades 9–10 (15-year-olds). One hundred and thirty-eight students were from a public metropolitan school in Bangkok province, and 125 were from a public rural school in Suphanburi province. The main testing method was divided into two procedures. First, pilot testing was conducted to confirm the reliability, validity, and internal consistency of the program and the exam questions, followed by field testing methods, which researchers used to identify the effectiveness of content design. Data analysis involved a quantitative research approach using a paired *t*-test to find the difference in scores between the preand post-tests. Analysis of variance (ANOVA) was used to analyse and find the relationships between improvements in scores and variables.

**Findings** – The results indicated that the selected patterns of content and design were effective in mathematics and reading subjects and in both rural and metropolitan areas. In addition, the academic achievement, accumulated (overall) grade point average (GPAX), significantly influenced improvements in reading subjects, and the intelligence indicator (IQ) had a significant effect on mathematic subjects in both areas. Furthermore, students' satisfaction had an effect on learning abilities in most student groups.

**Significance** – This pattern of design content may be significant for both instructors and program designers. This study provided a way of designing effective e-learning content that integrated effective indicators to identify potential students and improve their abilities. This pattern can be integrated with active learning. This blended learning model might be the new solution to solving problems with low-performing students in rural areas.

**Keywords**: E-learning design, e-learning method, e-learning effectiveness, variables that influence e-learning results.

## INTRODUCTION

Education is one of the key fundamental factors that contribute to a country's development and growth. As a country is working towards sustainable social and economic growths, quality, productive, innovative and skilled labour forces are needed across all sectors, and education is essential to producing such quality professionals. Equal access to basic education is one of the key success factors in human resource and sustainable development of economy and society. As the United Nations Development Programme (UNDP) report (2012) mentions, growth in public spending on education is correlated with growth in Human Development Index. However, the Organisation for Economic Co-operation and Development (OECD) (2012a) reported that almost one of five students does not achieve a basic education. Students who live in low socio-economic circumstances are more likely to be low-performing students because of inferior social and personal conditions that are obstacles to their educational abilities. Hence, access to quality education is as important as improving quality and learning outcomes of the education at all levels.

Even though the basic educational system in Thailand provides free education from kindergarten to high school, the system is failing in terms of effectiveness and accountability (Tangkitvanich, 2013). Many schools in Thailand are rural and low-income schools (RLISs), and most students are low-performing students who do not have the opportunity to complete a standard education (Suebnusorn & Chalamwong, 2013). Most teachers have to teach several subjects, including some in which they have limited experience. Therefore, there is a clear policy to encourage young people to access quality education. One of the key policies is the new education system that is applying technology to teaching and learning. The Thai government set up a knowledge-based plan under the National Information Technology (IT) policy framework (IT 2010). The vision was to provide Internet access to Thais, promote the use of IT for lifelong education, and efficiently improve quality of life and the environment. This was the first step to incorporate e-learning into Thai education (Ministry of Information and Communication Technology, 2008).

E-learning is considered a new solution to bridge the inequality gap in education in many developing countries, i.e., Pakistan, Nigeria, and Thailand (Iqbal & Ahmad, 2010; Folorunso, et al., 2006; Siritongthaworn, et al., 2006). Several new approaches in e-learning, such as massive online open courses (MOOCs), virtual reality (VR), and gamification, have been designed for students in leading educational countries to support their own cultures. However, a massive problem arises when these technologies are applied to other countries (Folorunso, et al., 2006; Siritongthaworn, et al., 2006). In addition, e-learning still suffers from other problems. Students resist adapting from traditional classrooms to computer-led training in virtual classrooms (Sanchez-Gordon & Luján-Mora, 2014). Moreover, many schools lack necessary e-learning equipment, such as highly efficient devices and Internet connections. Students also lack skills in computer literacy and self-motivation (Randy, 2011). Most previous studies on the effectiveness of e-learning have discovered many interesting findings. Suanpang and Petocz (2006) and Zirkin and Sumler (1995) focused on methods that influenced learning effectiveness. They examined effectiveness by comparing two modes (interactive and non-interactive) with a traditional method (classroom instruction). The results indicated that e-learning in interactive mode was better than e-learning in non-interactive mode. Moreover, it could replace traditional teaching. Andrew and Bradley (2005) and Henry (2008) studied factors that influenced effectiveness. The two main factors were internal factors, i.e., students' experience and motivation or satisfaction and external factors like the environment, instructors, technology, course flexibility or design and models. In addition, Amirtha and Florence (2015), De-Marcos et al. (2016) and Allen and Seaman (2007) examined the effectiveness and suitability of e-learning models, i.e., MOOCs and gamification. They reported that e-learning models were the effective educational platform. However, e-learning models still suffered from specific problems. For example, MOOCs are faced with problems with methods of assessing massive numbers of students and those with plummeting completion rates, and gamification still has problems in terms of effectiveness.

However, most previous studies on e-learning have rarely examined the effectiveness of design or the sequences of the context and content. Examples are the design of interfaces, the design and sequencing of examples and exercises, and the best methods of explaining contexts. Therefore, this paper describes an investigation into the platform and design of content of e-learning by considering two different subjects (mathematics and reading) and two areas (metropolitan and rural). What influences and to what degree internal variables, viz., intelligence, students' experience, motivation, and satisfaction, have on learning improvements (exam scores) are also investigated.

## LITERATURE REVIEW

### E-learning Model

There have recently been several new approaches in the education sector. MOOCs represent a new model that can support massive numbers of learners and open access through websites such as

Coursera, Edx, and the Khan Academy (Bozkurt et al., 2015). Gamification is a learning model that applies game mechanics to motivate people to achieve their objective (Huotari & Hamari, 2012).

Additionally, learning management systems (LMSs) represent one of the most popular approaches for planning, delivering, and managing learning in organizations (Martinez & Jagannathan, 2012). The modular object-oriented dynamic learning environment (Moodle) is an open access e-learning program and is probably the most widely used learning management system at present (Sach, 2012). Moodle has features such as student dashboards, progress tracking, mobility, and friendly themes (Moodle, 2014). However, there is some difficulty in using Moodle because of students' lack of skill and knowledge of its use (Paragia et al., 2011). Moodle was chosen from research planning as the e-learning program because it provides powerful tools to adjust the context and manage the classroom. Moreover, Moodle is a user-friendly and open source platform.

## E-learning and Education in Thailand

The basic educational system in Thailand is divided into three levels. The early three years of school are KG1-3 (3- to 5-year-olds). Primary or elementary school is called Prathom (6- to 11-year-olds). Secondary school is called Mattayomsuksa, covering M1-6 (12- to 18-year-olds) (Ministry of Education, 2013).

Thai education quality is failing in terms of effectiveness and accountability (Tangkitvanich, 2013). Many schools in Thailand are rural and low-income schools (RLISs) that have less than 600 students with low family incomes. Moreover, most students are low-performing students. The Ministry of Education (2013) reported that 1.6 million Thai children were unable to read or write because rural schools lack teachers, teaching materials, and infrastructure (Lathapipat et al., 2015). Most teachers have to teach several subjects, including some in which they have limited experience. Although the Thailand government spends a large proportion of its national budget on education, the education system is still performing badly. The Programme for International Student Assessment (PISA) reported that Thai students had the lowest academic scores in East Asia (Tangkitvanich, 2013).

Therefore, e-learning was established to fill this inequality gap. It provided effectiveness in terms of learning content and instructional quality. Even though e-learning is a powerful approach to solving the problems in Thai education, it still has obstacles to overcome. Muangkeow (2007) and Boodao (2009) reported that there were not enough technicians, e-learning professionals, instructors, hardware, or software for Thai e-learning. Instructors did not have sufficient time to focus on preparing online content. Moreover, students could not access e-learning systems outside institutes. Siritongthaworn et al. (2006) also found that Thai students had limited access to appropriate devices and Internet connections. In addition, Vate-U-Lan (2007) examined the readiness of e-learning in Thai public secondary schools and reported that only 70.6% of rural schools were ready for e-learning in terms of infrastructure and equipment. However, all schools in Bangkok (capital city) were ready to teach students through e-learning.

## Educational Assessment

Standardized educational tests are effective instruments administered to students to evaluate aptitude, abilities, knowledge, and capabilities (USNEI, 2008). Different tests and assessment systems have been applied in different countries. There are many indicators in Thai educational assessment, which are standardized measurements of varying levels of achievement, at every level of the Thai education system. First, accumulated grade point average (GPAX) is calculated by transforming the percentage of scores in each subject by the credits to accumulate grade points. The range is between 1.00 and 4.00. This indicator is a global standard and is organized by each school (Ministry of Education, 2013). Second, the ordinary national educational test (O-NET) is used to assess three levels of: elementary school (grade 6), lower secondary school (grade 9), and upper secondary school (grade 12). It is comprised of eight major subjects and is used to test about two million students every year.

PISA is a valid international instrument that measures the skills and abilities of 15-year-old students (OCED, 2012b). The PISA of mathematics includes four content categories: changes and relationships, spaces and shapes, quantities, and uncertainties and data. This test can be organized to include a spread of items to focus on important mathematical phenomena (OCED, 2013). Moreover, there are three broad aspects of reading. First, access and retrieval involve retrieving information and finding details about context. Second, development and interpretation for integration and interpretation form a broad understanding. Third, reflection and evaluation involve drawing knowledge and attitudes from the text and evaluating their form and content (OCED, 2013).

## Learning Framework

Aldrich (2004) provided six criteria for the learning framework of an educational simulation that can be divided into two groups: content types and delivery elements. Content includes linear content, which is step-by-step instruction; cyclical content, which is "muscle memory" such as playing piano or tennis; and system content, which addresses the complex relationships between conditions and interactions. Second, delivery includes pedagogical elements that ensure that learning is effective; game elements that offer entertaining interactions; and simulation elements that provide reality.

From the learning methodology to providing environment, instructional systems design (ISD) system creates instructional experiences for the acquisition of knowledge and skill (Merrill et al., 1996; Clark, 2002). There are several models, but many are based on the analysis, design, development, implementation, and evaluation (ADDIE) model (Duffy & Cunningham, 1996).

Due to the learning framework used in this research, only three phases of the ADDIE model were used. First, analysis provides information about tasks that students need to be trained to accomplish. Next, design is the blueprint for the learning process. Clark (2002) proposed four main elements: receptive, directive, guided discovery, and exploration. These design architectures provide various learning experiences, i.e., absorbing, doing, interacting, and reflection to learners (Wertenbroch & Nabeth, 2000; Dewey, 1993). Finally, there are two main methods of development to provide content to learners: deductive, having learners to generate general information as an example, and inductive, which provides learners with an example to abstract (Merrienboer, 1997).

### Students' Satisfaction

Wu et al. (2010) defined satisfaction as students' attitudes that resulted from all the utilities of an e-learning environment. Students' perception of learning experience can influence their decisions to continue learning (Carr, 2000; Barreto et al., 2017), which affects their satisfaction (Kenny, 2003). Moreover, Drennan et al. (2005) found that positive perception of technology and an innovative learning style are also positive attributes of students' satisfaction. There is a significant relationship between cultures and learning that is reflected in learning preferences. Students' satisfaction levels are related to individual characteristics and students' ages (So, 2009). Instructors are the main predictors of course satisfaction, and they have a positive correlation with students' performance. Students' satisfaction is also positively associated with their performance, grade-point averages (GPAs), and course completion rates (Bower & Kamata, 2000).

Palloff and Pratt (2009) identified eight elements for evaluating an online course. These were the main criteria used to design the student's satisfaction questionnaire in this research: perception of course experience, orientation to courses, quality and quantity of content, discussion and interaction, self-assessment of participation and performance, course management system, technical support, and access to resources.

## METHODOLOGY

The main propose of this study was to investigate the suitable patterns and design of content in e-learning by considering two different subjects (mathematics and reading) and areas (metropolitan and rural). Mathematics and reading subjects were chosen to assess the abilities of Thai students in e-learning because they are fundamental to all subjects. Moreover, the level of content (Bloom's taxonomy) (Anderson et al., 2000), subjects based on PISA classifications (OCED, 2013), learning framework, and Moodle LMS (Moodle, 2015) were the main tools we used to investigate quantitative learning abilities and identify the correct patterns and designs suitable for different groups of students. In terms of quantitative learning improvement, we simultaneously investigated internal factors, viz., the intelligence indicator (IQ), learning achievements (GPA), students' experiences, and satisfaction that influenced the results (exam scores).

The results from this experiment were divided into four sections. The results for hypotheses *H1-H10* in the first section indicate how effective learning improvements were through the level of content based on Bloom's taxonomy, which classified the level of exam difficulty into three levels: remembering and understanding, application and analysis, and evaluation and creation (Anderson et al., 2000). Moreover, the exam subjects were mathematics (changes and relationships, spaces and shapes, quantities, and uncertainty and data) and reading (access and retrieval, integration and interpretation, reflection and evaluation) (OCED, 2013). This experiment tested both metropolitan and rural student groups. Testing different assumptions was conducted through a paired *t*-test to determine the difference in scores between the pre- and post-tests.

*H1* : *There is a significant difference between pre- and post-test scores in a group of metropolitan students for both subjects.*

*H2* : *There is a significant difference between pre- and post-test scores in a group of rural students for both subjects.*

*H3* : *There is a significant difference between pre- and post-test scores in a group of metropolitan students for mathematics, based on the PISA classifications.*

*H4* : *There is a significant difference between pre- and post-test scores in a group of metropolitan students for reading, based on the PISA classifications.*

*H5* : *There is a significant difference between pre- and post-test scores in a group of rural students for mathematics, based on the PISA classifications.*

*H6* : *There is a significant difference between pre- and post-test scores in a group of rural students for reading, based on the PISA classifications.*

*H7* : *There is a significant difference between pre- and post-test scores in a group of metropolitan students on the level of content (Bloom's taxonomy) in mathematics.*

*H8* : *There is a significant difference between pre- and post-test scores in a group of metropolitan students on the level of content (Bloom's taxonomy) in reading.*

*H9* : *There is a significant difference between pre- and post-test scores in a group of rural students on the level of content (Bloom's taxonomy) in mathematics.*

*H10* : *There is a significant difference between pre- and post-test scores in a group of rural students on the level of content (Bloom's taxonomy) in reading.*

Assumptions *H11-H16* in the second section were tested to examine various relationships and how they influenced learning improvements, based on three internal factors, i.e., GPAX, IQ, and Ordinary National Educational Test (O-NET) scores. Students were separated into two groups depending on whether they belonged to metropolitan or rural groups. They were also tested on mathematics and reading. This section describes the ANOVA we conducted to analyse and identify the relationships between improvements in scores and internal factors. Tukey's honest significant different (HSD) test was used to analyse subsequent effects.

*H11* : *The GPAX of mathematics subjects has a significant effect on score improvements in both areas.*

*H12* : *The GPAX of reading subjects has a significant effect on score improvements in both areas.*

*H13* : *IQ has a significant effect on score improvements in mathematics in both areas.*

*H14* : *IQ has a significant effect on score improvements in reading in both areas.*

*H15* : *O-NET math scores have a significant effect on score improvements in mathematics in both areas.*

*H16* : *O-NET reading scores have a significant effect on score improvements in mathematics in both areas.*

Assumptions *H17–H20* in the third section were tested to identify the relationships between learning improvements and two background factors: satisfaction and e-learning experience. These factors were examined with learning outcomes in both areas and both subjects. ANOVA was used to find the relationships between score improvements and background factors.

*H17* : *Students' satisfaction will have a significant effect on score improvements in mathematics in both areas.*

*H18* : *Students' satisfaction will have a significant effect on score improvements in reading in both areas.*

*H19* : *Students' experience will have a significant effect on score improvements in mathematics in both areas.*

*H20* : *Students' experience will have a significant effect on score improvements in reading in both areas.*

The final section involved the results from testing hypothesis *H21* to find learning improvements in groups of students classified by their IQ and GPAX scores. Students were classified into six groups: high GPAX and high IQ scores (Group 1), high GPAX and medium IQ scores (Group 2), medium GPAX and high IQ scores (Group 3), medium GPAX and medium IQ scores (Group 4), low GPAX and high IQ scores (Group 5), and low GPAX and medium IQ scores (Group 6). Differences in pre- and post-test scores from these six groups of students were evaluated by area and subject to identify the relationships between GPAX and IQ factors in scores. Because there was no low IQ student group, that group was excluded from the observations. A paired *t*-test was conducted to determine the differences in scores from pre- and post-tests.

*H21* : *There is a significant difference between score improvements in groups of students in different subjects and areas.*

Researchers have defined learning effectiveness to evaluate research models, as summarized in Figure 1, to achieve research purposes.

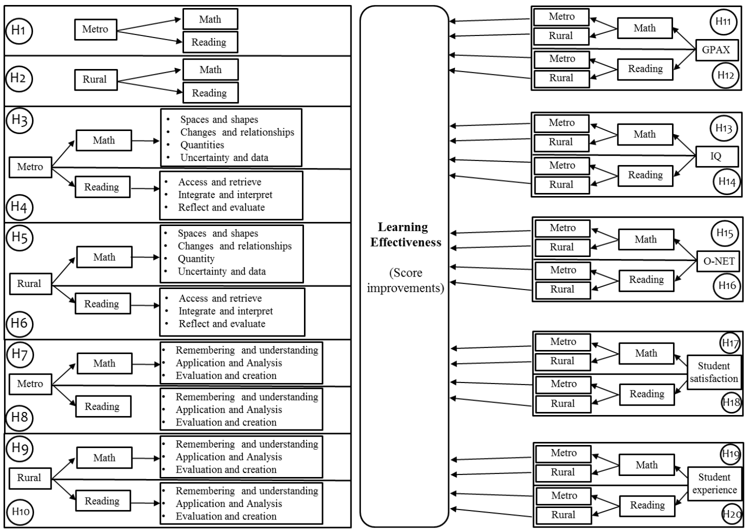


*Figure 1*. Learning effectiveness to evaluate research model.

## Participants

The data were collected using field testing methods in two different schools. The participants were 263 randomly selected students (138 from a public metropolitan school in Bangkok province) and 125 from a public rural school in Suphanburi province). The tested students were in grade 9 (15 years old), which was consistent with PISA. Out of the 263 respondents, 48.85% were male and 51.14% were female. The majority of students had a medium GPAX (38.93%), 34.07% had a low GPAX, and 27% had a high GPA. The majority group in the O-NET mathematics scores was the medium-scoring group (44.65%), but the majority group in O-NET reading was in the low-scoring group (48.47%). For the IQ indicator, 82.06% had an average IQ score and 18.32% had a high average IQ score. However, there were no low average IQ students in this data collection.

## Research Learning Framework

The learning framework used in this research was adapted from the ADDIE model (Duffy & Cunningham, 1996), instructional system design (ISD) (Clark, 2002), six criteria for educational stimulation (Aldrich, 2004), Bloom's taxonomy (Anderson et al., 2000), and four instructional design model (Merrienboer, 1997). This framework was adapted in this study to design the patterns and content of video presentations and exercise context design (Figure 2).

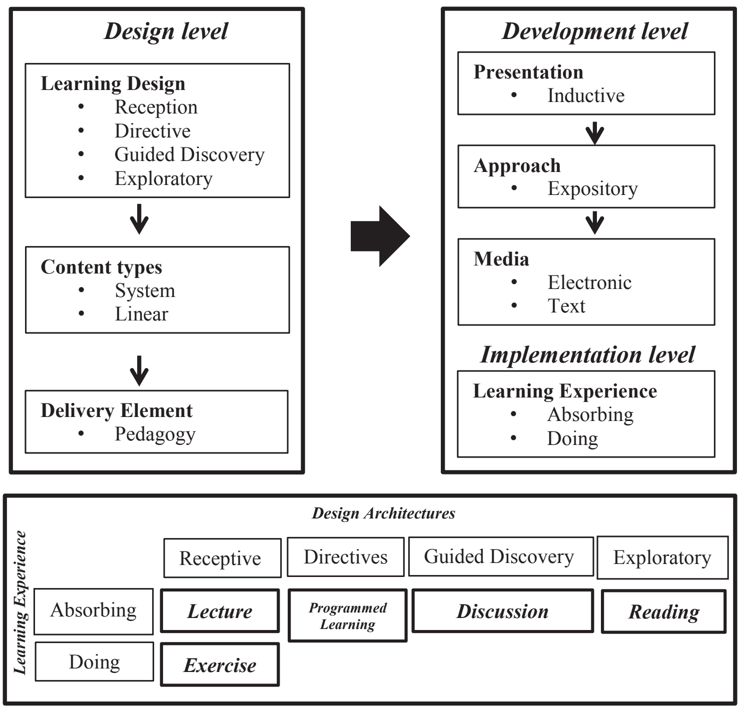


*Figure 2*. Learning framework used in this research.

This framework combined three levels of e-learning program construction (Duffy & Cunningham, 1996). First, it provided the design architecture at the design level, which determined the depth of learning. We combined receptive, directive, guided discovery, and explorative elements in this work (Clark, 2002) with six levels of Bloom's taxonomy of remembering, understanding, applying, analysing, evaluating, and creating (Anderson et al., 2000) to design the level of content and difficulty of context. Moreover, two content types determined the direction of flow of content: linear and system (Aldrich, 2004). Researchers do not use cyclical content types because they require muscle memory that is not suitable for e-learning. In addition, delivery elements determine interfaces that only use pedagogy or teaching by instructors (Aldrich, 2004) because of limitations with time and Moodle features. Second, inductive and expository instructional strategies, which present examples and then present general information such as case studies and programmed learning (Merrienboer, 1997), are used at the development level. Our main purpose was to provide the content in a program by using electronics as media to be the channel to deliver the context. Third, the implementation level determined the experience of learners using two elements, adsorbing and doing (Wertenbroch & Nabeth, 2000), but did not use interaction and reflection because this e-learning program was designed for electronic interaction by using blogs and Web chats. The activities that required face-to-face interactions and group work were eliminated. Moreover, two concepts of learning design architecture and learning experience were combined to make up the design matrix, which used five strategies. First, the program provided the context through lectures and reading and then used programmed learning to provide immediate feedback to learners in the exercise part. In addition, learners participated and discussed feedback with instructors using Web chats and blogging.

## Program Framework and Instruments

The main methods in terms of primary data were divided into two parts: the proposed pattern and content of e-learning design utilizing the Moodle open source program (Moodle, 2015), and the processes and steps to assess the effectiveness of this pattern and content design. The results provided statistics that pinpointed how effective or ineffective our proposed e-learning design was. In addition, it helped identify internal factors that influenced the e-learning effectiveness. The first section was devoted to creating an e-learning program and several tests with e-learning content. The aim was to confirm the validity of the program and the exam questions. First, an e-learning program from an open source program (Moodle, 2015) was created. Our e-learning program was unique as it aimed to create comprehensive understanding of the subjects to emphasize the six levels of Bloom’s taxonomy (Anderson et al., 2000) and learning framework. Second, e-learning exam questions were modified from the Thai version of the PISA (Years 2003, 2006, and 2012) in mathematics and reading subjects. PISA was utilized because it is by far the most internationally accepted test, with levels in line with Bloom's six levels. Third, a validity test was carried out by conducting the item objective congruence index (IOC) (Rovinelli & Hambleton, 1997). IOC provided results from three experts in their academic fields. When a result was positive, we proceeded by using that set of exam questions for our pilot test. Pilot testing was then carried out on 20 students. Reliability and internal consistency were measured using the Kuder-Richardson formula 20 test (KR-20) (Kuder & Richardson, 1937), which was aimed at evaluating and reconstructing the exam from the test results of the 20 students. After pilot testing had been completed, a real pre-test was field tested.

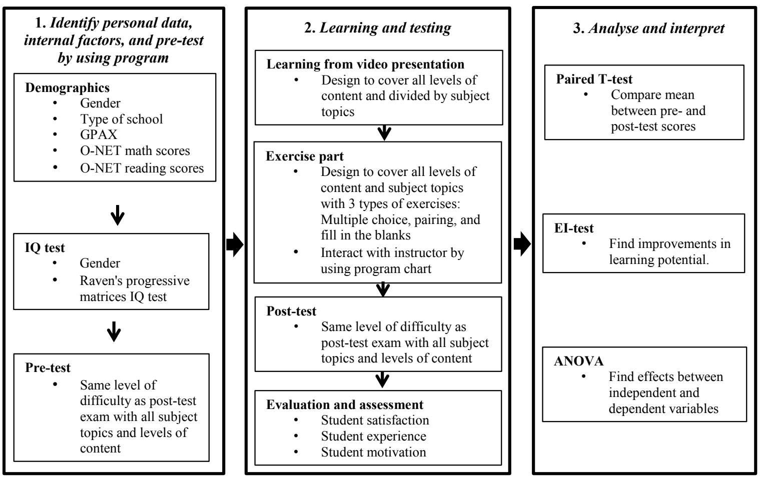


*Figure 3*. Field data collection process and interpretation

An e-learning program can be divided into eight steps (see Figure 3). The first involves providing personal data and internal factors that might influence the learning process. Student profiles are collected on four items: gender (male or female), type of school (public metropolitan or public rural), GPAX (below 2.00, 2.00–3.00, and 3.00–4.00) (Ministry of Education, 2013), and O-NET scores (below 50%, 50–80%, and over 80%) (NIETS, 2014).

The second step involved respondents completing the 40-question IQ test (Raven, 2014) through which they were classified into three IQ ranks (below 90, 90–109, and over 110) (Saklofske et al., 2003).

The third step involved respondents answering questions 9–12 in the pre-test exam. The exams we utilized were developed based on Bloom's taxonomy into three group levels: remembering and understanding, application and analysis, and evaluation and creation (Anderson et al., 2000). Moreover, the exams were separated by subject topics of mathematics (changes and relationships, spaces and shapes, quantities, and uncertainty and data) and reading (access and retrieval, integration and interpretation, and reflection and evaluation) (OCED, 2013). Three or four questions per level and per subject constituted both the pre- and post-tests. In all, 9–12 questions were prepared. The post-test exam was administered after the students had gone through the learning materials and completed their exercises. The level of difficulty was programmed to match that of the pre-test exam.

The fourth step involved respondents learning content from the proposed e-learning program, which was developed with a learning framework, PISA topics (OCED, 2013), and Bloom's taxonomy (Anderson et al., 2000). The participants learned two subjects (mathematics and reading) through the same constructed e-learning program.

The fifth step involved respondents completing exercises to enhance their understanding. The exercise parts consisted of pairing, multiple choice, fill in the blank, and true-false quizzes.

Respondents were given a post-test in the sixth step. E-learning satisfaction and experience were evaluated in the seventh step. A paired t-test was utilized, together with effectiveness index (EI) (Goodman, Fletcher & Schneider, 1980) and ANOVA (Anscombe, 1948) to fully assess the effectiveness of the e-learning program. The paired *t*-test compared the means between the pre- and post-test scores. The EI was used to find improvements in learning potential in terms of percentages. ANOVA was administered to find the effects and relationships between variables.

**Evaluation and Assessment Questionnaire**

Evaluation and assessment questionnaires were written in Thai using a three-point Likert scale: one = not agree, two = partly agree, and three = agree. The questionnaire consisted of two constructs to assess satisfaction and experience. First, students' satisfaction was measured using eight elements, following the study by Palloff and

Pratt (2009). Second, students' experience referred to the personal experience of students who had learned through an e-learning program before this experiment. These two physical factors were examined after students had used the e-learning program.

## RESULTS

The first assumption, *H1*, in metropolitan areas and the difference in pre- and post-test scores was statistically significant at a level of 0.01 in both mathematics (*t*-value = -11.7) and reading (*t*-value = -13.26). The second assumption, *H2*, in rural areas and the difference in pre- and post-test scores was also statistically significant at a level of 0.01 in both mathematics (*t*-value = -7.76) and reading (*t*-value = -7.1). The third assumption, *H3*, in mathematic subjects, indicated that the difference in pre- and post-test scores was statistically significant at a level of 0.01, which could be divided into four types of content: spaces and shapes (*t*-value = -3.89), changes and relationships (*t*-value = -5.12), quantities (*t*-value = -4.85), and uncertainty and data (*t*-value = -5.45). The fourth assumption, *H4*, in reading subjects, indicated the difference in pre- and post-test scores was also statistically significant at a level of 0.01. Three classifications of content were access and retrieval (*t*-value = -8.87), integration and interpretation (*t*-value = -4.58), and reflection and evaluation (*t*-value = -7.48). The next assumption, *H5*, in mathematic subjects indicated the difference in pre- and post-test scores was statistically significant at a level of 0.01, divided into four types of content: spaces and shapes (*t*-value = -3.36), changes and relationships (*t*-value = -3.99), quantities (*t*-value = -3.61), and uncertainty and data (*t*-value = -7.88). The sixth assumption, *H6*, in reading subjects indicated the difference in pre- and post-test scores was also statistically significant at a level of 0.01. Three classifications of content were access and retrieval (*t*-value = -6.32), integration and interpretation (*t*-value = -5.38), and reflection and evaluation (*t*-value = -3.42). The seventh assumption, *H7*, in mathematic subjects indicated the difference in pre- and post-test scores was statistically significant at a level of 0.01, which could be divided into three levels: remembering and understanding (*t*-value = -9.87), application and analysis (*t*-value = -6.72), and evaluation and creation (*t*-value = -3.74). The eighth assumption, *H8*, in reading subjects indicted the difference in pre- and post-test scores was also statistically significant at a level of

0.01, in three types of content: remembering and understanding (*t*-value = -9.03), application and analysis (*t*-value = -6.82), and evaluation and creation (*t*-value = -6.63). The ninth assumption, *H9,* in mathematics was divided into three levels: remembering and understanding (*t*-value = -7.26), application and analysis (*t*-value = -7.67), and evaluating and creation (*t*-value = -0.46). However, the difference in pre- and post-test scores was not statistically significant in mathematics because of the evaluating and creation level (*p*-value = 0.64, which exceeded 0.05). The tenth assumption, *H10*, in reading subjects indicated the difference in pre- and post-test scores was also statistically significant at a level of 0.01, divided into three types of content: remembering and understanding (*t*-value = -5.02), application and analysis (*t*-value = -4), and evaluation and creation (*t*-value = -3.53).

Table 1

*Results from t-test for Assumptions H1–H10*

| Hypotheses | *t*-values | Test | Acceptance |
|---|---|---|---|
| ***H1:*** | | *t*-Test | ***Accepted*** |
| *Metropolitan areas: Mathematics subjects* | -11.7** | | Accepted |
| *Metropolitan areas: Reading subjects* | -13.26** | | Accepted |
| ***H2:*** | | | ***Accepted*** |
| *Rural areas: Mathematics subjects* | -7.76** | | Accepted |
| *Rural areas: Reading subjects* | -7.1** | | Accepted |
| ***H3:*** | | | ***Accepted*** |
| *Metropolitan areas: Mathematics: Space and shape content* | -3.89** | | Accepted |
| *Metropolitan areas: Mathematics: Change and relationship content* | -5.12** | | Accepted |
| *Metropolitan areas: Mathematics: Quantity content* | -4.85** | | Accepted |
| *Metropolitan areas: Mathematics: Uncertainty and data content* | -5.45** | | Accepted |

(continued)

| Hypotheses | *t*-values | Test | Acceptance |
|---|---|---|---|
| ***H4:*** | | | ***Accepted*** |
| *Metropolitan areas: Reading: Access and retrieval content* | -8.87** | | Accepted |
| *Metropolitan areas: Reading: Integration and interpretation content* | -4.58** | | Accepted |
| *Metropolitan areas: Reading: Reflection and evaluation content* | -7.48** | | Accepted |
| ***H5:*** | | | ***Accepted*** |
| *Rural areas: Mathematics: Space and shape content* | -3.36** | | Accepted |
| *Rural areas: Mathematics: Change and relationship content* | -3.99** | | Accepted |
| *Rural areas: Mathematics: Quantity content* | -3.61** | | Accepted |
| *Rural areas: Mathematics: Uncertainty and data content* | -7.88** | | Accepted |
| ***H6:*** | | | ***Accepted*** |
| *Rural areas: Reading: Access and retrieval content* | -6.32** | | Accepted |
| *Rural areas: Reading: Integration and interpretation content* | -5.38** | | Accepted |
| *Rural areas: Reading: Reflection and evaluation content* | -3.42** | | Accepted |
| ***H7:*** | | | ***Accepted*** |
| *Metropolitan areas: Mathematics: Remembering and understanding level* | -9.87** | | Accepted |
| *Metropolitan areas: Mathematics: Application and analysis level* | -6.72** | | Accepted |
| *Metropolitan areas: Mathematics: Evaluation and creation level* | -3.74** | | Accepted |
| ***H8:*** | | | ***Accepted*** |
| *Metropolitan areas: Reading: Remembering and understanding level* | -9.03** | | Accepted |
| *Metropolitan areas: Reading: Application and analysis level* | -6.82** | | Accepted |

(continued)

| Hypotheses | *t*-values | Test | Acceptance |
|---|---|---|---|
| *Metropolitan areas: Reading: Evaluation and creation level* | -6.63** | | Accepted |
| ***H9:*** | | | ***Rejected*** |
| *Rural areas: Mathematics: Remembering and understanding level* | -7.26** | | Accepted |
| *Rural areas: Mathematics: Application and analysis level* | -7.67** | | Accepted |
| *Rural areas: Mathematics: Evaluation and creation level* | -0.46 | | Rejected |
| ***H10:*** | | | ***Accepted*** |
| *Rural areas: Reading: Remembering and understanding level* | -5.02** | | Accepted |
| *Rural areas: Reading: Application and analysis level* | -4** | | Accepted |
| *Rural areas: Reading: Evaluation and creation level* | -3.53** | | Accepted |

*$p<0.05$

**$p<0.01$

The results for assumption *H11* in the second section of mathematic subjects indicated that GPAX did not have an effect on the difference in pre- and post-test scores for either metropolitan (F-value = 0.68) or rural areas (F-value = 0.85). The next assumption, *H12*, for reading GPAX had a significant effect on the difference between pre- and post-test scores in both metropolitan (F-value = 12.79) and rural areas (F-value = 28.21). Tukey's HSD test indicated that in reading, metropolitan students who had a high GPAX (3.50–4.00) had a statistically significant higher mean in their differences in pre- and post-test scores (*p*-value = 0.01). However, rural students who had a low GPAX had a statistically significant lower mean in differences between pre- and post-test scores (*p*-value = 0.01). There were no significant differences in the results for pre- and post-test score means in medium and high GPAX groups. Therefore, a high and medium GPAX group should be selected if we want high scores. The next assumption, *H13*, in mathematics IQ had a significant effect on differences between pre- and post-test scores in both metropolitan (F-value = 16.516) and rural areas (F-value = 20.25). The next assumption, *H14*, in reading IQ did not have a significant effect on score improvements in either metropolitan (F-value = 0.29) or rural areas (F-value = 1.09). The following assumption, *H15*, in O-NET math scores had a significant effect on the difference in pre- and post-test scores in both metropolitan (F-value = 39.05) and rural areas (F-value = 32.91). The HSD test indicated high O-NET math score groups (over 80%) in metropolitan areas had statistically significant higher means in the differences in pre- and post-test scores (*p*-value = 0.01). In contrast, high O-NET math score groups in rural areas had statistically significant higher means in the results for pre- and post-test scores (*p*-value = 0.01), followed by the medium and low O-NET math score groups. The next assumption, *H16*, indicated that the O-NET reading score had a significant effect on the difference in pre- and post-test scores in both metropolitan (F-value = 53.73) and rural areas (F-value = 41.97). The high O-NET reading score group (over 80%) had a statistically significant higher mean of difference in pre- and post-test scores (*p*-value = 0.01) from the HSD test in metropolitan areas, followed by the medium and low O-NET reading score group. We also found high O-NET reading score groups in rural areas had a statistically significant higher mean of difference in pre- and post-test scores (*p*-value = 0.01). There were no significant differences in the results for pre- and post-test score means for low and medium O-NET reading score groups.

Table 2

*Results from ANOVA test for assumptions H11–H16*

| Hypotheses | F-values | Test | Acceptance |
|---|---|---|---|
| ***H11:*** | | ANOVA | ***Rejected*** |
| *Metropolitan area: Mathematics subjects GPAX* | 0.68 | | Rejected |
| *Rural areas: Mathematics subjects GPAX* | 0.85 | | Rejected |
| ***H12:*** | | | ***Accepted*** |
| *Metropolitan areas: Reading subjects GPAX* | 12.79** | | Accepted |

(continued)

| Hypotheses | F-values | Test | Acceptance |
|---|---|---|---|
| *Rural areas: Reading subjects GPAX* | 28.21** | | Accepted |
| ***H13:*** | | | ***Accepted*** |
| *Metropolitan areas: Mathematics subjects IQ* | 16.51** | | Accepted |
| *Rural areas: Mathematics subjects IQ* | 25.2** | | Accepted |
| ***H14:*** | | | ***Rejected*** |
| *Metropolitan areas: Reading subjects IQ* | 0.29 | | Rejected |
| *Rural areas: Reading subjects IQ* | 1.09 | | Rejected |
| ***H15:*** | | | ***Accepted*** |
| *Metropolitan areas: Mathematics subjects O-NET* | 39.05** | | Accepted |
| *Rural areas: Mathematics subjects O-NET* | 42.04** | | Accepted |
| ***H16*** | | | ***Accepted*** |
| *Metropolitan areas: Reading subjects O-NET* | 53.73** | | Accepted |
| *Rural areas: Reading subjects O-NET* | 39.78** | | Accepted |

**p<0.05*

***p<0.01*

Assumption *H17* in the third section in students' satisfaction with mathematics had a significant effect on score improvements in both metropolitan (F-value = 1.89) and rural areas (F-value = 12.59). Assumption *H18* for students' satisfaction with reading did not have an effect on score improvements in metropolitan areas (F-value = 2.83), but it did have a significant effect in rural areas (F-value = 4.95). Assumption *H19* for students' experience with mathematics did not have an effect on score improvements in either metropolitan (F-value = 1.14) or rural areas (F-value = 7.11). Assumption *H20* for students' experience did not have a significant effect on score improvements in rural areas (F-value = 0.6), but it had a significant effect in metropolitan areas (F-value = 7). The HSD test indicated that low-experience groups had a statistically significant higher mean of differences in pre- and post-test scores ($p$-value = 0.01). There were no significant differences in the results for pre- and post-test score means for high- and medium-experience groups.

Table 3

*Results from ANOVA for assumptions H17–H20*

| Hypotheses | F-values | Test | Acceptance |
|---|---|---|---|
| ***H17:*** | | ANOVA | ***Accepted*** |
| *Student satisfaction: Metropolitan areas: Mathematics subjects* | 1.89* | | Accepted |
| *Student satisfaction: Rural areas: Mathematics subjects* | 12.59** | | Accepted |
| ***H18:*** | | | ***Rejected*** |
| *Student satisfaction: Metropolitan areas: Reading subjects* | 2.83 | | Rejected |
| *Student satisfaction: Rural areas: Reading subjects* | 4.95* | | Accepted |
| ***H19:*** | | | ***Rejected*** |
| *Student satisfaction: Metropolitan areas: Mathematics subjects* | 1.14 | | Rejected |
| *Student satisfaction: Rural areas: Mathematics subjects* | 1.8 | | Rejected |
| ***H20:*** | | | ***Rejected*** |
| *Student satisfaction: Metropolitan areas: Reading subjects* | 7.11** | | Accepted |
| *Student satisfaction: Rural areas: Reading subjects* | 0.6 | | Rejected |

*$p<0.05$

**$p<0.01$

Four minor hypotheses for assumption *H21* were tested for the final section. The difference in pre- and post-test scores in metropolitan areas were statistically significant at a level of 0.01 in both mathematics and reading. Group 1 in both mathematics (*t*-value = -16.33) and reading (*t*-value = -10.07) performed the best in learning improvements. Moreover, Group 1 in mathematics post-test scores improved 98% from the pre-test scores and 100% in reading. The difference in pre- and post-test scores for rural areas was statistically significant in mathematics, but not statistically significant in reading. In addition, Group 5 in mathematics (*t*-value = -5.26) and Group 1 in reading (*t*-value = -11) performed the best in learning improvements. Group 5's mathematics post-test scores improved 49% from the pre-test scores, and Group 1 reading post-test scores improved 47% from pre-test scores.

Table 4

*Results from t-test for assumption H21*

| Hypotheses | | *t*-values | Test | Acceptance |
|---|---|---|---|---|
| ***H21:*** | | | *t*-Test | ***Rejected*** |
| ***Metropolitan area: Mathematics subjects*** | | | | |
| *Group1: High GPAX* | *High IQ* | -16.33** | | Accepted |
| *Group2: High GPAX* | *Medium IQ* | -5.03** | | Accepted |
| *Group3: Medium GPAX* | *High IQ* | -10.33** | | Accepted |
| *Group4: Medium GPAX* | *Medium IQ* | -6.5** | | Accepted |
| *Group5: Low GPAX* | *High IQ* | - | | - |
| *Group6: Low GPAX* | *Medium IQ* | -5.38** | | Accepted |
| ***Metropolitan areas: Reading subjects*** | | | | |
| *Group1: High GPAX* | *High IQ* | -10.07** | | Accepted |
| *Group2: High GPAX* | *Medium IQ* | -7.92** | | Accepted |
| *Group3: Medium GPAX* | *High IQ* | -4.58* | | Accepted |
| *Group4: Medium GPAX* | *Medium IQ* | -7.42** | | Accepted |
| *Group5: Low GPAX* | *High IQ* | - | | - |
| *Group6: Low GPAX* | *Medium IQ* | -4.16* | | Accepted |
| ***Rural areas: Mathematics subjects*** | | | | |
| *Group1: High GPAX* | *High IQ* | -3.95* | | Accepted |
| *Group2: High GPAX* | *Medium IQ* | -1.41 | | Rejected |

(continued)

| Hypotheses | | *t*-values | Test | Acceptance |
|---|---|---|---|---|
| *Group3: Medium GPAX* | *High IQ* | -3.86 | | Rejected |
| *Group4: Medium GPAX* | *Medium IQ* | -3.37* | | Accepted |
| *Group5: Low GPAX* | *High IQ* | -7.38** | | Accepted |
| *Group6: Low GPAX* | *Medium IQ* | -3.48* | | Accepted |
| ***Rural areas: Reading subjects*** | | | | |
| *Group1: High GPAX* | *High IQ* | -1.33 | | Rejected |
| *Group2: High GPAX* | *Medium IQ* | -1.16 | | Rejected |
| *Group3: Medium GPAX* | *High IQ* | -2.98* | | Accepted |
| *Group4: Medium GPAX* | *Medium IQ* | -2.86 | | Rejected |
| *Group5: Low GPAX* | *High IQ* | -2.23 | | Rejected |
| *Group6: Low GPAX* | *Medium IQ* | -5.83* | | Accepted |

*$p<0.05$

**$p<0.01$

## DISCUSSION

Researchers found from the results that the selected pattern of content was effective for most sample groups and subjects. The results were consistent with those from the previous findings by Noble (2002), Noble (2004), and Maher (2004), who reported that students who were taught using Bloom's taxonomy content design benefited in terms of learning outcomes and problem-solving. Moreover, these results also aligned with those obtained by Mayer (2001), who stated that taxonomy provides meaningful learning in which students invest their effort and time to achieve tasks.

Due to subject topic testing, metropolitan students improved more in the learning process than rural students in three topics: spaces and shapes, changes and relationships, and quantity content. However, rural students improved more in uncertainty and data content. The improvements in reading of learning by integrating and interpreting content appeared to be equal for both areas. However, in access, retrieval, reflecting, and evaluating content, metropolitan students still improved more than rural students. Students in both areas on the level of content improved the same in mathematics applications and analysis levels. Surprisingly, rural students did not improve on the evaluating and creating level, which is the hardest level of mathematics. We suspected the main reason is that rural areas had few high-IQ students and IQ scores had a significant effect on improving mathematical learning. Metropolitan students improved more than rural students in both subjects for the remaining levels. From the results, metropolitan students still outperformed rural students in term of learning outcomes in most of the criteria because of computer literacy, e-learning readiness, and social influence. Siritongthaworn et al. (2006) reported that Thai rural schools have limited access to consistent Internet quality and appropriate devices, especially outside school. Most students can only use computers at school within limited times and have difficulty accessing e-learning materials and appropriate software. This report was in line with Vate-U-Lan (2007), who examined e-learning readiness in Thai metropolitan and rural public secondary schools and found that all metropolitan schools were ready for e-learning, while only 70.6% of rural schools had appropriate devices and infrastructures.

Additionally, internal factors influenced the learning process. GPAX had a significant effect on improvements in reading in both areas. Metropolitan students who had high GPAX had more significant score improvements in reading than other groups. Rural students who had medium or high GPAX had greater improvements than those in low GPAX groups. GPAX, on the other hand, did not have a significant effect on mathematics in either area. Although GPAX measures accumulated the average scores of both calculating and reading subjects, there were usually more reading than calculating subjects in class; therefore, reading had a greater effect than calculating subjects for GPAX. This was similar to the findings by Wright (1962), Maxwell (1971), Stack-Cutler et al. (2015), and Bergey et al. (2015), who reported that the association between reading improvements and gains in academic achievements (GPA) was statistically significant and had positive correlations. Moreover, IQ had a significant effect on mathematics in both areas but did not have a significant effect on reading because IQ measures intelligence including short-term memory and analytical thinking (Saklofske et al., 2003). Evans et al. (2002) and Blaira et al. (2005) further reported that increasing IQ scores represented an increase in mental abilities and cognitive skills that correlated with calculating and mathematical abilities. Finally, two scores (mathematics and reading) were chosen for the O-NET test, which is the national educational test of Thailand. The O-NET scores for both subjects and both areas had a significant effect on improved scores because they individually measure each subject. They indicated specific students' improvements for each subject.

The evaluation part involved two factors: satisfaction and experience. First, students' satisfaction had a significant influence on learning improvements for both subjects in rural areas. However, it also had a significant effect in metropolitan areas but only on mathematics. Pang and Lee (2013) and Hassan et al. (2010) supported this finding, stating that satisfaction (intrinsic motivation) effectively enhanced academic achievements and learning outcomes. If students have higher levels of satisfaction, they tend to achieve better academic outcomes. Second, students' experience did not have an effect on learning improvements in rural areas or on mathematics in metropolitan areas. However, it had a significant effect on reading in metropolitan areas. Surprisingly, students who had low levels of experience in e-learning improved the most in their group. This contradicts Haverila (2011), who reported that prior e-learning experience was correlated with learning outcomes. We suspected that the differences in content design and program interfaces were the reasons behind this contradiction.

Finally, every group in group classification in metropolitan areas significantly improved their scores. Moreover, Group 1 had the best improvement in scores in both subjects, i.e., 98% improvement in mathematics and 100% in reading. All groups in rural-area mathematics significantly improved their scores. In addition, Group 5 had the best improvement in mathematics learning (49% improvement). Groups 5 and 6 in reading had no significant improvements in scores because these two groups had low GPAX, which has a significant effect on scores. This indicates that instructors should focus more on low-level GPAX rural students in reading when they are learning through e-learning.

## CONCLUSION AND FUTURE WORK

The pattern of content, which was designed by integrating the learning framework, subject topics (PISA classifications) (OCED, 2013), and the level of content (Bloom's taxonomy) (Anderson et al., 2000), was effective in both subjects and both areas, but using this pattern with metropolitan students was still more effective than for rural students because of technology and computer literacy. This learning pattern should be considered a guideline for e-learning content design. The instructor should follow the pattern of content. It would be a good indicator to identify and improve students' abilities. In addition, learning indicators like GPAX and IQ are specific measures of the learning abilities of students in different subjects. A national test like O-NET, on the other hand, is more efficient for identifying student abilities in both reading and math. Moreover, students' satisfaction influenced most student groups. Instructor and program designers should be concerned with students' views and their preferences. E-learning programs can be used with any students even if they do not have e-learning experience.

Researchers intend to integrate this pattern of content and design with active learning in future work to solve education problems in rural areas and identify important factors and features that positively affect student retention. This blended learning model involves combining student-centred learning (active learning) and teacher-centred learning (e-learning). Students can exercise control over time, place, path, or pace. This model might be the new solution to solving problems with low-performing students.

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