

## Development of Mathematics Curriculum to Promote Learning and Innovation Skills of the 21<sup>st</sup> Century through the Application of Lesson Study

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### Abstract

*This paper delineates the application of professional learning Development (PLD) or "Lesson Study", according to Inprasitha [8]. The process was employed by the researchers together with math staff collaboratively to design math curriculum for grade 7 students in Wieng JD Wittaya High School (WJDWS), Lamphun Province located in northern Thailand. Rationales behind the study are two folds, improving student math achievement and skills important in 21<sup>st</sup> skill. The Lesson Study Process explicitly outlines three steps for designing curriculum systematically. The steps of the process include Collaboratively Design Lesson (Plan), Collaboratively Observe the Lesson (Do), and Collaboratively Reflect or Post Discuss the Lesson (See). The Thai Ministry of Education currently mandates the instruction for math and science in public schools be delivered in English and to promote learning and innovation skills of 21<sup>st</sup> century. Delivery content in a language that is different from the students' first language is not an easy task. To meet the two requirements, the Open Approach method which allows students to have high engagement in learning activities, to be able to question their teachers for clarification, and to take risk voicing their opinions towards irrational propositions. The theorist advocates that this method of instruction will promote students critical thinking skills and learning achievement. After launching the curriculum, it can be concluded that overall 91% of students were pleased with the way the math instruction were taught to them.*

### 1. Introduction

The world has changed from the industrial focus to knowledge and skills based. People in today's world people are competing in the expanding global marketplaces. Success in school is not the only factor for students to find jobs or survive anymore. Schools must prepare the students with both knowledge and essential skills that will help them adjust themselves and be able to live in the changed world. Unlike previous centenary, the 21<sup>st</sup> century students must learn life skills and also core contents

such as math, science, economics, literacy, etc., [11]. Schools should prepare their students with such skills for them to survive in the fast pacing technological and competitive world comfortable. The curriculum in the 21<sup>st</sup> century has different emphasis from the previous. Teachers play an important role in designing the curriculum that will prepare students who equip with knowledge and skills that are vital to live in the changed world.

Thailand is one of the Asian countries that is approaching the ASEAN Economic Community (AEC) community encompasses ten countries beginning 2015. In spite of their countries own or primary language, it is consent that education in these countries will be offered in two routes: (1) English will be the instructional language for delivering Math content that we know as Mini English Program (MEP) or English Program (EP), and (2) English will be an instructional language for math and science as known for the world-class standard school. In either route, each country's native language remains the primary language that all their children must learn.

The major goals for math curriculum are in Thailand were to prepare its students with mathematical thinking skills as well as communicative skills in English, orally and in writing. The recent test results for math by Trends in International Mathematics and Science Study (TIMSS) and the Program for International Student Assessment (PISA) displayed low math achievement in Thai students who took these tests. Out of 41 countries taking TIMSS in 2011, Thailand ranked 27 on the list. For PISA, Thailand ranked 51 of 65 countries took the test.

Because of the aforementioned reasons, schools have to design the curriculum in accordance with the national policy in order to promote students' English fluency and to prepare its students with knowledge and skills necessary for 21<sup>st</sup> century economic and fast pacing world.

The traditional ways of teaching math will not serve the two purposes of Thai education. Teachers worked in isolation to teacher their own students. As aforementioned the living in the 21<sup>st</sup> century world comfortably, people need to know to communicate with other thru social media. Much knowledge and skills are acquired via

communication. The traditional ways of teaching do not lend teachers to have opportunities to meet and plan lessons collaboratively with their teacher peers. The curriculum needs to be modified and adjusted to meet the needs of the current society needs. However, teachers had no chance to discuss among teachers. Time is another challenge that teachers encountered. There is no time allocated for teachers to collaborate and to share their teaching strategies among their colleagues. Like teachers in other countries, Thai teachers were also assigned extra duties that they have to carry daily. Such activities include school administration, lunch duty, recess, finance, open house, teacher-parent conference, etc. Thai teachers may also be assigned duties from the regional educational officials such as math camp, Dhamma workshop, or other special events as assigned. The Lesson Study lend opportunities to teachers plan lessons together and teach same lesson plans. Teachers also have a chance to reflect each lesson with their peers and readjust the lesson to better meet their students' needs instead of doing it in isolation. Thus, the Lesson Study process was introduced to WJDWS High School along with Open Approach method to deliver math instruction.

## 2. Lesson Study

Lesson study is a Japanese model of professional development, which teachers would be engaged in to improve the quality of their teaching and enrich students' learning experiences. Furthermore, Lesson Study creates a friendlier working environment and individual work change in the culture of a school [5]. Six steps of the Lesson Study Process by Fernandez and Yoshida [4] are as follows:

- Step1: Collaboratively Planning the Study Lesson
- Step2: Seeing the Study Lesson in Action
- Step3: Discussing the Study Lesson
- Step4: Revising the Lesson
- Step5: Teaching the New Version of the Lesson
- Step6: Sharing Reflection about the New Version of the lesson

In Thailand, this idea had getting started on 2002 in the northeast of Thailand by Center for Research in Mathematics Education (CRME), the Faculty of Education, Khon Kaen University [7] and into the north of Thailand, Chiang Mai University on 2009. For the process of Lesson Study researcher adapted for three steps revised by Inprasitha [8] following by Figure 1.

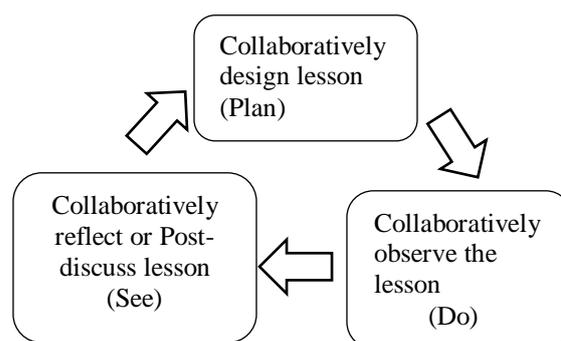


Figure 1: Process of Lesson Study

- Step1: Collaboratively design lesson (Plan)
- Step2: Collaboratively observe the lessons (Do)
- Step3: Collaboratively reflect or post-discuss lesson (See)

The process requires teachers' high commitment, dedication and willingness. Changes also require time, persistence and patience. Getting teachers to start and to engage in designing curriculum using the Lesson Study process are the two most challenging factors. The process was introduced to WJDW High School beginning May 2013. It took five months (May to September) for the teachers to accomplish the first draft of math curriculum. It was expected that the current developed based on the Lesson Study process will serve the two major purposes of the Thai policy for education.

## 3. Methodology

### 3.1. Participants

The study was conducted through the effort of the following academic leaders and teaching staff in WJDW HS. The academic leaders included Academic Vice Director, Chief of Academic, Research and Human Resources Development, Curriculum and Instruction, and Mathematics Department Chair. Teaching staff included eight mathematics teachers and the researcher.

### 3.2. Objective

The objective was to develop Mathematics Curriculum to Promote Learning and Innovation Skills of 21<sup>st</sup> Century through the Application of Lesson Study.

### 3.3. Data collection

The study was conducted following the qualitative method. The first four steps of Lesson Study framework simplified by Inprasitha [8] were employed to construct the curriculum for math and lesson plans for grade 7 students in WJDWS. Data analysis include of videotapes of all time teachers meeting and students studying in class , written lesson plan, student work, researchers’ field notes, teachers and students interview. Following is the data collecting process.

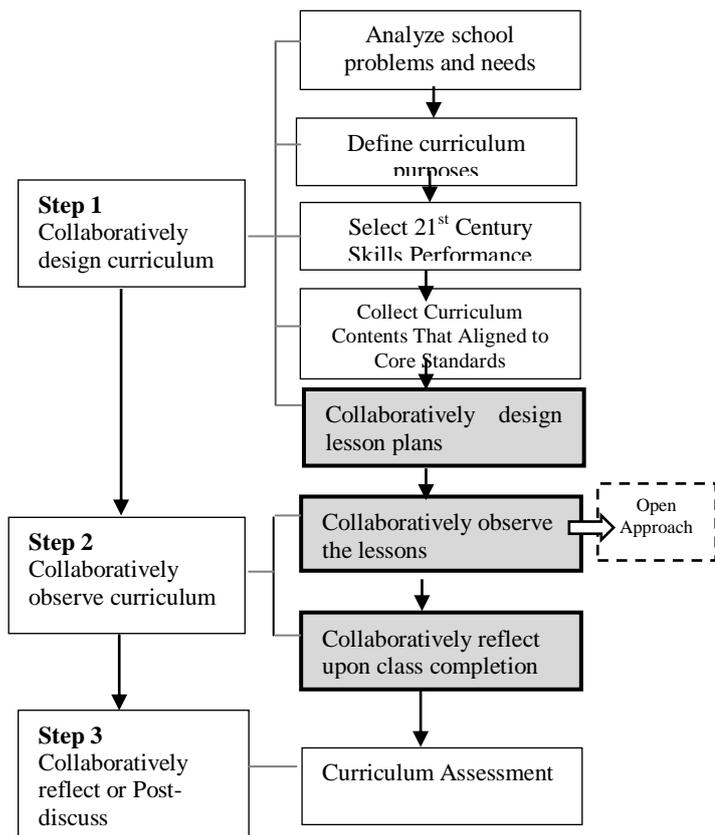


Figure 2. Research Method

### 4. Results

The results of the study are presented in the below section.

#### Step 1: Collaboratively Design Curriculum

In this step, the researchers as well as eight math teachers collaboratively designed curriculum following the sub steps listed below.

- Determine School Problems and Needs

The school lead researcher met with the five academic leaders to identify school problems and needs. The lead researcher explained to the

researcher follows how the proposed curriculum would cultivate WJDWS to become a world-class standard school, where math and science instruction would be delivered in English with the instruction that will promote the students’ higher thinking skills.

The study found almost all of the teachers did not emphasize higher thinking skills due to time limit and the mandate from Ministry of Education that math instruction must be delivered in English. Another problem majority of our teachers encountered was lacking English proficiency skills. These teachers were not equipped to teach math in a second language, which is English.

The lead researcher then presented the necessity for our students to possess the 21<sup>st</sup> century skills so they can compete with the fast pacing economic world. Learning and Innovation Skills in 21<sup>st</sup> Century Skills by the Partnership for 21<sup>st</sup> Century Skills Framework (Figure 3), which related to the world-class standard school project consisting of four skills including critical thinking and problem solving, creativity and innovation, communication and collaboration were introduced to the WJDWS academic leaders.

The four 21<sup>st</sup> century skills aligned with the two indicators of the world class standard school. The first standard is to build at least the communication skills in two languages for our students. It is expected that a high percentage of our students in grades 7-9 (M1-M3) can communicate orally in English fluently. Our students will be able to perform their assigned tasks that required creativity and critical thinking skills. All fellow researchers consent to construct the curriculum following the Lesson Study Process.



Figure 3. The framework of 21<sup>st</sup> Century Skills by the Partnership for 21<sup>st</sup> Century Skills

- Define the Curriculum Purposes

The purposes of the study were defined by the lead researcher and the rest of her fellow researchers. Prior to determine the study purpose, the school policies, the 21<sup>st</sup> century skills as well as the process of Lesson Study were described to the researcher group including the eight math teachers. The Thai Ministry of Education mandates that all instruction in math must be delivered in English and higher

thinking skills must be promoted in daily instructional activities.

The four learning and innovation skills (1) critical thinking and problem solving, (2) creativity, (3) communication and (4) collaboration along with the three steps for Lesson Study process were introduced to the teachers. The steps include Collaboratively Design Lesson (Plan), Collaboratively Observe the Lesson (Do), and Collaboratively Reflect or Post Discuss the Lesson (See). The outputs from this step were used to develop math curriculum and lesson plans for grade 7 students in WJDWS.

The instruction was delivered to WJDWS 7<sup>th</sup> graders using the Open Approach strategies by Isoda [9]. The developers suggested necessary steps when delivering instruction to students. The steps include posing problem, estimating the ways of solutions, independent solving, explanation and comparison, and integration and applications. The above steps were then modified by Inprasitha (2010) into four steps as presented in Figure 4 below.

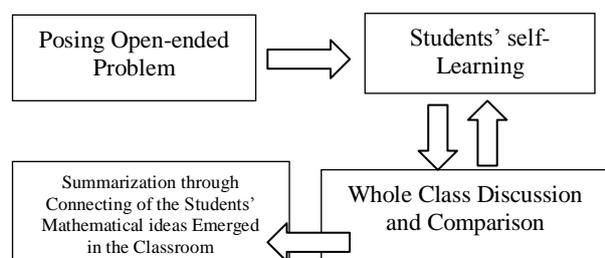


Figure 4. Four Steps of Open Approach as a Teaching Approach (Inprasitha, 2010)

The Posing Open-Ended Problem phase may be conducted in three different ways, process is open, end products are open, and ways to develop are open. In the Students' Self-Learning phase, students were broken into small of two to six depending upon the type of problem, number of students and classroom space. Approximately 15-20 minutes were allocated for this phase. Each group worked independently to solve the problem using any ways that they may deem possible. When the time was, the students then returned to the whole group to share and discuss the strategies they used to solve the given problem. Each group compared similarity and differences of their methods for solving their problem.

Summarization through Connecting of the Students' Mathematical Ideas Emerged in the Classroom is the last phase of instruction cycle. During this time period, the teachers may pose questions for the students to involve in summarizing the main mathematical concept learned in that period.

Upon completion of pre-study meeting, the leader researcher asked for math teachers who wanted to volunteer to develop the math curriculum

for WJDWS grade 7 students. All math teachers were interested in the research project. They all felt the proposed project will be beneficial to improve their math instruction and learning. They believed that the process will allow opportunities to them to work collaboratively with their fellow teachers. The project also allowed them to share their teaching experiences and tactics of math teaching with their colleagues. More important, the proposed project would meet the mandates from the Ministry of Education. Besides the aforementioned, the teachers would be able to conduct action research with their colleagues.

The practice prior to the proposed project, each teacher worked in isolate. There was no time allocated for them to plan or share ideas each other. Unlike the previous practice, the proposed project allocated 2-hour weekly planning time on Tuesdays for teachers to plan their lessons together.

- Select 21<sup>st</sup> Century Skills Performance Standards  
A workshop regarding Open-Approach method was conducted for five math teachers who were able to attend the training. The teachers watched the video of a teacher who would deliver a math lesson via Open Approach method.

After the workshop, the teachers worked collaboratively to identify essential math learning behaviors, which emphasize Learning and Innovation Skills for 21<sup>st</sup> Century. The identified behaviors were the framework for math curriculum in WJDWS grade 7 students. Following are the lists of expected behaviors.

#### Critical Thinking and Problem Solving

- ✓ Verbal and Written Reasoning
- ✓ The Propensity to Seek Reason
- ✓ Inquisitiveness in Open-ended Problem
- ✓ Making Decision in Solving Problem
- ✓ Interpreting and Explaining
- ✓ Making Another Choice and Convincing Others with Appropriate Reasons
- ✓ Engaging in Analyzing Each Other's Answer
- ✓ Solving Open-ended Problem
- ✓ Analyzing Arguments, Claims, or Evidence.

#### Creativity and Innovation

- ✓ Generating ideas, Often by Thinking Divergently Using Fluency and Originality
- ✓ Being Tolerant of Ambiguity
- ✓ Willing to Take Intellectual Risks
- ✓ Generating New and Variety ideas
- ✓ Expressing Different Ideas
- ✓ Generating Learning Style or Tools

#### Communication

##### Mathematics communication

- ✓ Rephrasing Other's Explanation
- ✓ Engaging in Questions and Discussion

- ✓ Paying Attention to Others’ Reasons
- ✓ Effectively Communicating Math Concepts Orally and in Writing
- ✓ Selecting Appropriate Reading Strategies for Open-ended Problems

*English communication*

- ✓ Using Basic English to Share Ideas Verbally and in Written
- ✓ Being Able to Follow Verbal and Written Instructions and Being Able to Follow
- ✓ Being Able to Articulate Math Expressions

**Collaboration**

- ✓ Being Able to Express Math Problems with Peers and Teachers
- ✓ Having Sense of Team Work
- ✓ Sharing Ideas and Listening to Others’ Perspectives
- ✓ Negotiating to Get Consent

- Collect the Contents for Curriculum

Focus group including all researchers (except vice-director) and eight math teachers cooperatively selected math standards that relate to 21<sup>st</sup> Century Skills and the Basic Education Core Curriculum 2008. In summary, four units with subunits were established to be taught in 32 hours or a semester as presented in Table 1 below.

**Table 1. Curriculum Framework**

Unit	Sub-unit	Contents	(4c’s)	hr
1.Integer Numbers	Investigating Accounts	Integer Numbers	C1,C4	1
	Negative Numbers	Number on Number line Opposite number	C1,C3	1
	Where am I?	Addition of Integer number	C1,C2, C3,C4	2
	Change the sign	Subtraction of Integer number	C1	1
	Eat and don’t eat	Multiplication of Integer number	C1	2
	Divided me!	Division of Integer number	C1	3
	Numbers properties	Properties of positive integer	C1	1
2.Powers	I am a power	Powers form Element of Power	C3	1
	Operation of powers	Power’s solution	C1	2
	Multiplication property	Multiplication of powers $a^n \cdot a^m = a^{n+m}$ $(a^n)^m = a^{n \times m}$	C1,C3	3
	Division property	Division of power	C1	1

		$\frac{a^n}{a^m} = a^{n-m}$		
	How big am I?	Scientific notation	C1,C2	2
	Alien Game	Solution of Powers	C1	2
3.Basic Geometry	Yes, I am!	Point, line, line segment, ray, right angle, acute angle, obtuse angle	C2,C3, C4	1
	How to construct (1)?	Line segment’s construct	C2,C4	4
	How to construct (2)?	Angle’s construct and split angle	C2,C4	3
4.Math Project	My project (oral presentation)	Presentation Game in Math	C2,C3, C4	2
<b>Total</b>				<b>32</b>

*C1-Critical Thinking and Problem Solving; C2-Creativity and Innovation; C3-Communication, C4-Collaboration*

- Collaboratively Design Lesson Plan

In this phase, all researchers (except vice director for academic) and eight math teachers worked cooperatively constructed lesson plans. The plan included instructional activities, media, questions and assessments: Integer Numbers, Powers, Basic geometry and Math Projects. The objectives for each units and subunits were carefully determined. The objectives must be aligned with the Basic Education Core Curriculum 2008 for Mathematics and 21<sup>st</sup> Century Skills in Learning and innovation skills.

In this paper, the researcher will only present the process of developing a sample lesson plan for a sub unit, Investigating Account under Unit 1 (Integer Numbers). The steps are as follows: (1) Teachers share their strategies in teaching Integer Numbers (positive & negative numbers). An example presented by a teacher was that Sombat was given 80 baht to purchase two kilograms of apples for his mom. When he reached the market, he found that a kilogram of apples costs 50 baht. The teacher then asked the students to help Sombat to solve the problem. At this point, the teacher wanted her students to find ways to solve the problem for Sombat, so that he could fulfil his mom’s need.

Another teacher proposed that the thermometer may be used to represent the temperature since the number in the thermometer could be 0 or below zero. Some teachers voiced different opinions that it was a proper way to introduce negative numbers to students using the thermometer as it may create confusion for students. For example, -5 is less than < -2; however, the students may think that the temperature at -5 is colder than -2. According to some of the teachers’ experience, the students

interpreted that  $-5$  temperature is greater than  $-2$  temperature, which is opposite. The teachers then agreed that the thermometer may not be an appropriate device to introduce the concept of negative numbers to the students in this level. The above only a couple of sample mentioned in this paper to create Open-Ended problems.



Figure 5. Collaboratively Designed Lesson

### Step 2: Collaboratively Observe Curriculum

- Collaboratively Observe the Lessons

The designed lessons were taught the lead researcher using Open Approach process. The Open Approach composes of four steps including (1) Posing Open-ended Problem, (2) Students' Self-Learning, (3) Whole Class Discussion and Comparison, and (4) Summarization through Connecting of the students' Mathematical Ideals Emerged in the Classroom. The rest of the research participants collaboratively took turn to observe the instruction as presented in Figure 6 below.



Figure 6. Collaboratively Observe the Lesson

The researchers met to discuss today's lesson, objectives, expected learning behavior and observation form. The research participants used the form to record the expected learning behaviors as presented in Table 1 in the above section.

- Collaboratively Reflect after Class Completion

Normally, all researchers met to reflect the lesson at Professional Learning Community (PLC) session, which was scheduled for Tuesdays. When necessary, the researchers would conduct reflection right after completion of the lesson to prevent the loss and accuracy of information. The participants then shared their observation in regard to the students' learning behaviors. The data derived from PLC meeting were used to modify the lesson plan to better meet the needs of students. The students who did not meet the performance target were retaught before moving to the next lesson.

### Step 3: Collaboratively Reflect or Post-Discuss

- Curriculum Assessment from participants

Researchers and math teachers met to reflect experience encountered during the Lesson Study process. The lead researcher presented the video regarding the project from the curriculum construction to the implementation of the lesson to the students. Each researcher first worked independently to reflect experience s/he obtained from the project. Comments and recommendations were also welcome during this time. Then, each shared their findings with their peers. The advantages and limitations of the project were identified.

The findings were concluded in three major areas. For majority of teachers, working cooperatively to improve students' learning behaviors with their colleague teachers was their first experience in their teaching life. Teachers felt more confident as they could learn from more experienced teachers. The students also learned higher-thinking skills through the Open Approach process. They also felt excited to learn math using English from a math teacher. As English instruction in math is mandated by the Ministry of Education, the project was well-served such intention.

- Curriculum Assessment from Students

After the end of the semester, the participating students were asked to participate in three research instrument including (1) a 5-rating Likert scale survey (1=Strongly Disagree, 2=Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree), (2) a reflection form, and (3) an interview consisting of three open-ended questions, which developed and conducted by the lead researcher under her academic adviser's supervision. At the end of the project, all students responded to the survey questions consisting of 16 items. They also wrote their reflection based on the question, "How do I feel about this class?"

However, only eight out of 42 students volunteered to participate in the interview session consisting of three topics as listed below:

Question 1: What is your opinion towards your learning?

Question 2: Which three learning activities that you like most? Why? (List three reasons.)

Question 3: How good is your English? Do you agree that learning math in English help improve your English? If your answer is no, please tell us your reason(s).

#### 4.1. The Findings of the Project

The findings were classified into three areas: instructional tools, student learning activities, and instructional strategies. Overall, 92% of the students agreed and strongly agreed that the instructional media used to deliver math instruction was interesting and encouraging them to learn math. For student learning activities, 92% indicated hands-on learning activities and activities that connected to their daily life help them understand the math problem better. They also express their interest in learning math using English instruction. About 90% of students stated that this instructional process allowed them to ask questions, to voice their own opinions, use different problem-solving strategies from that of the teacher's to solve problems, and have opportunities to collaborate with their peers to solve the problem. Overall, 91% of the students agreed and strongly that they were satisfied with the Open Approach Method.

#### 5. Discussion

In summary, it is evident in the aforementioned sections that the WJDWS Mathematics Curriculum Development was designed following the Lesson Study Process. The main purpose was to promote learning and innovation skills of the 21<sup>st</sup> century for grade 7 students in WJDWS in Lamphun, Thailand. Participating teachers worked collaboratively in developing the curriculum and lesson plans. It is noticeable that participating teachers were excited in the process of Lesson Study as it was a new innovation of teaching and learning to them. As presented in the aforementioned section that working teachers in the same field collaboratively planned lessons together, share teaching ideas to each other and worked together to solve the problems they encountered in their daily instruction. The Lesson Study process is somewhat similar to the PLC process by DuFour and Eaker [3]. PLC focuses on sharing mission, vision, and values, collective inquiry, collaborative team, an orientation toward

action and a willingness to experiment, commitment to continuous improvement, and a focus on results, which is a sustainable model of professional development for 21<sup>st</sup> century.

The investigation from participating teachers' reflection indicated that the school was satisfied with the curriculum that was constructed by the researchers based on the students' needs.

#### 6. Conclusion

In conclusion, WJDWS obtained the math curriculum, which the school expects to promote learning and innovation skills of 21<sup>st</sup> century for its students. The curriculum consists of four units with 17 sub units as presented in Table 1. The staff members were proud to be part of the project that the curriculum was developed based on their perspectives and school needs.

#### 7. Recommendation

It is recommended that the future study be included the intervention instruction for the students who do not master the learning target, or below the benchmark after the first learning. Additionally, research participants should participate in all steps in Lesson Study Process, which in turn will help them gather more information that may be vital to include in their reflection for improvement.

#### 8. Acknowledgement

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