Online Learning and Augmented Reality: Enhancing Students Learn Transformation Geometry During the Covid-19 Pandemic

Krongthong Khairiree
krongthong.kh@ssru.ac.th or drkrongthong@gmail.com
International College, Suan Sunandha Rajabhat University,
Bangkok, Thailand.

Abstract

The purpose of this study is to explore the students' perceptions of online learning self-study on Transformation Geometry using augmented reality, via smartphone. In the 2020, action research was conducted in Bangkok, Thailand. The total of 20 Lower Secondary students participated in this study. The duration of the action research was about two months from June to July 2020 during the Covid-19 pandemic in Thailand. The students had self-study through online learning lesson and used smart phone to scan QR Code Reader to explore Transformation Geometry: Translation, Reflection and Rotation animations and activities. Based on the students' interviews they revealed that they studied through online learning platform incorporated with augmented reality they were able to visualize contents in a textbook. Augmented reality animated content of Transformation Geometry and it made the concepts easier to learn and retain. However, more than 50% of the students revealed that they wanted to study in the normal classroom and used augmented reality in mathematics class.

1. Introduction

In 2020 the World Health Organization (WHO) declared the COVID-19 epidemic a pandemic [1]. In Thailand, Public health experts and Thai Government announced the policies that people had to do social distancing, self-isolation, quarantine and work from home. In accordance with the announcement from the Minister of Education, all schools and universities have to close more than three months in order to control the disease and reduce the spread of the COVID-19 virus [2]. Teaching and learning in all schools and universities were moved to online platforms. Augmented Reality (AR) was one of the tools that teachers created and embedded in learning instructions. Using AR linked to internet through a tablet or smartphone provide a rich learning experience to students during the period of self-isolation and work from home. In addition, with AR the students were able to explore the learning content themselves, which can made them feel more motivated to improve skills and knowledge [3].

A survey conducted by UNESCO [4] concluded that most education systems around the world implemented distance learning to ensure continuity of learning. Governments all over the world utilize technologies to remote learning opportunities for students while schools are closed. About 94% of learners worldwide were affected by the CIVID-19 pandemic [4]. The World Economic Forum explained the crisis could accelerate innovation within education. For those who do have access to the internet and necessary technology, there is evidence that learning online can be effective. The experience gained during the COVID-19 crisis, new digital learning possibilities could be implemented by educational institution to stimulate productivity of the lessons. Potential innovations include educational applications, platforms and resources [5].

2. Mathematics and the Geometer's Sketchpad (GSP)

The Ministry of Education Thailand announced the Revised Basic Education Core Curriculum in B.E. 2560 (A.D. 2017) and stated that students have to learn mathematics five hours per week and there are 16 weeks in one semester. The mathematics teachers have to complete the mathematics contents in the required syllabus and the assessments. Geometric transformations are one of core contents in the syllabus of lower secondary mathematics. One of the Strands in geometry stated that geometry students should be able to describe and analyze characteristics and properties. Students should be able to use visualization, spatial reasoning and geometric models in solving problems [6].

The dynamic mathematics software Geometer's Sketchpad (GSP) is identified as one of the key indicators in teaching and learning mathematics [6]. GSP was introduced in Thailand since Year 2000. GSP is one of mathematics software that provides opportunities for teacher to use GSP to facilitate students thinking about mathematical relationships. GSP empowers students to use their abilities to create graphical representation, to enable them in developing their mathematical thinking skills, concepts, and understand. In using GSP students learn by exploring, investigating and discovering. GSP enhance students' ability in helping them visualize abstract mathematical relationships and various problem structures through pictorial representations [7].

3. Transformation Geometry

Transformation geometry is the study of geometry focusing on groups of geometric transformations and properties. A transformation means a "*change*" in position, size or shape.
By moving all the points of a geometric figure based on certain rules, we can create an image of the original figure. This process is called *transformation.* Each point on the original object corresponds to a point on its image. The image of point A after a transformation of any type is called point A' [8].

Types of transformation geometry in the secondary mathematics syllabus consist of translation, reflection and rotation [9] as follows:

1) Translation: Slide an object

A *translation* is a transformation which moves all points on a plane through the same distance in the same direction.

2) Reflection: Flip an object

A *reflection* is a "flip" of an object over a mirror line. There are two common reflections: *a horizontal reflection* and *a vertical reflection*.

3) Rotation: Turn an object.

A *rotation* is a transformation that is performed by turning an object around a fixed point called a center of rotation at any angle degree measure.

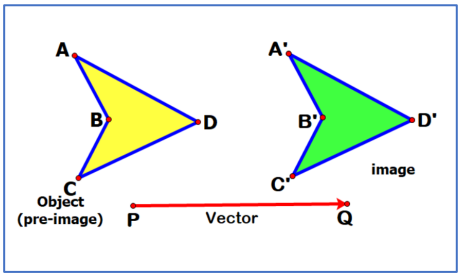


Figure 1: Translation

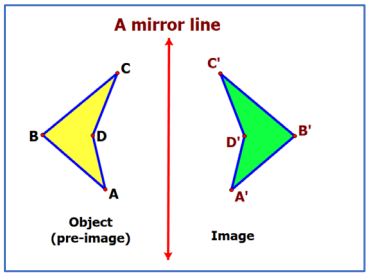


Figure 2: Reflection

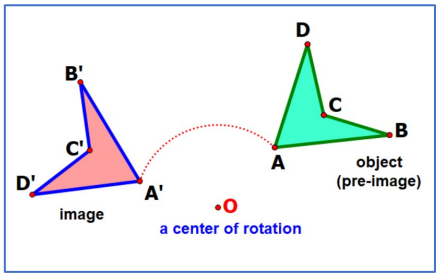


Figure 3: Rotation

4. Augmented Reality

Augmented Reality (AR) is a technology that superimposes computer-generates images and animations on top of real-world views. Augmented Reality enhance version of reality created by the use of technology to overlay digital information on an image of something being viewed through a mobile device such as a smartphone [10]. AR enhances students' experiences by adding virtual components such as digital images, graphics or sensations as a new layer of interaction with the real world. The mathematics textbooks materials with AR examples adds another dimension to the learning process - a process that will become a blended learning of the traditional approach and innovative practical illustrations of complicated concepts. AR animated figures and contents in mathematics lessons could catch students' attention and also motivate them to learn. The Augmented Reality is a type of AR where a smartphone is used to display and interact with virtual contents [11]. The students used smart phone to scan QR Code Reader to explore mathematics animations and mathematics activities prior attending class. By scanning at QR Code Reader on the printed targets the smartphone showed the animations of each steps in solving word problems and the students were able to interact with it [12].

5. SSRUIC MOOC, Teaching and Learning Mathematics During the Covid-19 and Action Research in Thailand

According to a survey on "UNESCO – COVID-19 Impact on Education" conducted by UNESCO explained that in order to switch to online learning, there are three requirements need to be fulfilled: access to the internet, the right technology and the skills to use the technology [13]. In order to support continuity in education, Thai Government granted funding to International College, Suan Sunandha Rajabhat University (SSRUIC) to develop massive open online courses namely SSRUIC MOOC. SSRUIC MOOC is free online courses available for Thai teachers and students to enroll. In April 2020, SSRUIC in collaboration with the Office of the Basic Education Commission (OBEC), Ministry of Education, Thailand conducted workshops on "*How to Develop Online Learning Modules in Mathematics?* There were more than 900 mathematics teachers from at least 300 schools participated in these workshops. The online learning lessons and materials developed from these workshops were selected and uploaded on SSRUIC MOOC.

The researcher selected one mathematics class of the teachers who participated in the said workshops to be a sample group of this action research. The researcher created mathematics lessons, activities and learning instructions incorporated with AR and GSP, and uploaded through SSRUIC MOOC.

6. Research Questions

The action research questions were:

1) How to implement contents and activities on transformations geometry using AR and GSP effectively?
2) What are the students' perceptions on using online learning platform and self-study on transformations geometry incorporated with AR, and GSP?

Question 1: How to implement contents and activities on transformation geometry using AR and GSP effectively?

The schools in Thailand were completely closed during June to July 2020 because of Covid-19 pandemic. The teaching and learning mathematics on transformation geometry using AR and GSP was employed as follows:

1) Teacher distributed handouts, lecture notes and exercises on transformation geometry to the students in the sample group;
2) Teacher taught transformation geometry via online learning platform SSRUIC MOOC; and
3) The students in the sample group learned mathematics on transformation geometry via online learning and self-study from lecture notes and used AR and GSP from their homes. The students used smart phone to scan at QR Code Reader to explore mathematics animations and mathematics activities. By scanning at QR Code Reader on the printed targets the smartphone showed the animations of each steps of transformations and the students were able to interact with it.

The following examples show lessons contents and activities on transformation geometry using AR and GSP.

Example 1: Construction of Translation

The students used GSP to construct a *translation* and explore the properties of translation. The following activities described how GSP and QR code can enhance students' understanding translation concepts. The construction of a translation using GSP are as follows.

- Open the Geometer's Sketchpad, in the File Menu, choose New Sketch and follows the instruction step-by-step.
- Use the point tool to construct points A, B, C, D, and E with many sides and construct polygon interior as shown.
- Construct segment ***PQ*** to indicate a direction and distance as follows:
  - Select in order from point ***P*** to point ***Q***
  - Go to *Transform menu* and select **Mark vector**
  - Click a polygon ABCDE and inside the interior of the polygon
  - Go to the *Transform menu* and select **Translate**
  - Change the color of the translated image
  - Label points A′,B′, C′, D′, and E′, and the translated polygon **" *image*"**

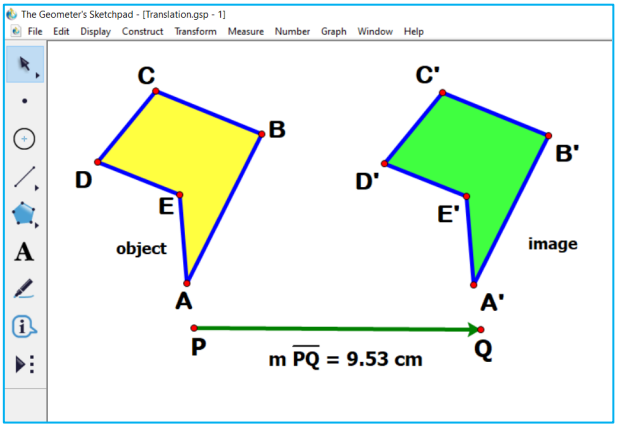


Figure 4: An Object and Its Image of the Translation

- Construct segments AA′ BB′, CC′, DD′, and EE′,
- Use Measure menu to measure segments PQ, AA′ BB′, CC′, DD′, and EE′,

- Drag point Q to change your vector, and observe the relationship between the translated image and the original figure. Hide segments BB′, DD′, and EE′,
  - Construct point ***F*** on segment AA′ and point ***G*** on segment CC′.
  - Construct a line through points ***F*** and ***G***.
  - Use Measure menu to measure angles ***CGF*** and ***GFA′***
  - Create animation buttons at points ***F*** and ***G*** to explore all pairs of corresponding angles, alternate angles, interior angles and properties of the translation.

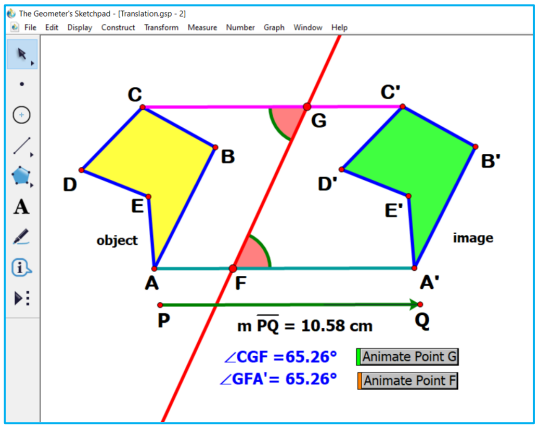


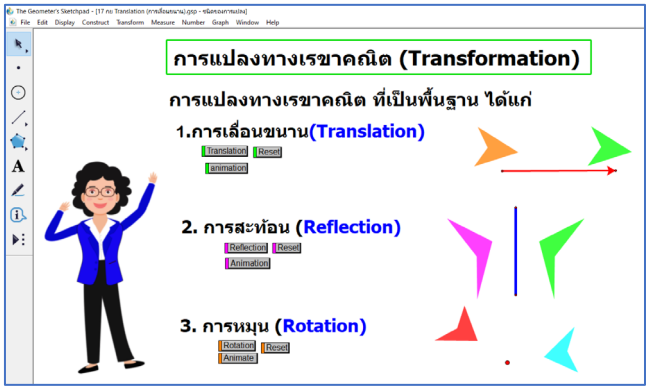
Figure 5: Exploration the Properties of the Translation

Example 2: Online Learning Lesson on Translation

The students in the sample group learned mathematics on translation geometry via online learning platform and self-study. They studied from handouts, lecture notes and exercises with AR and GSP from their homes. The example of the lecture notes on transformation lessons from the online learning platform are as follows.

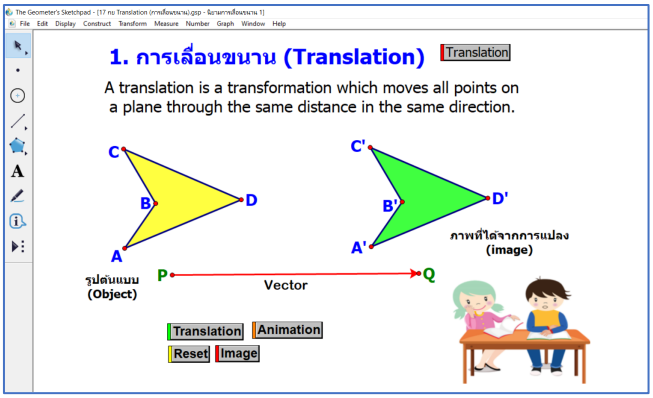
A **transformation** is a way of moving or changing a figure. There are three types of basic transformations that preserve the size and shape of the figure, namely.

- Translation
- Reflection
- Rotation



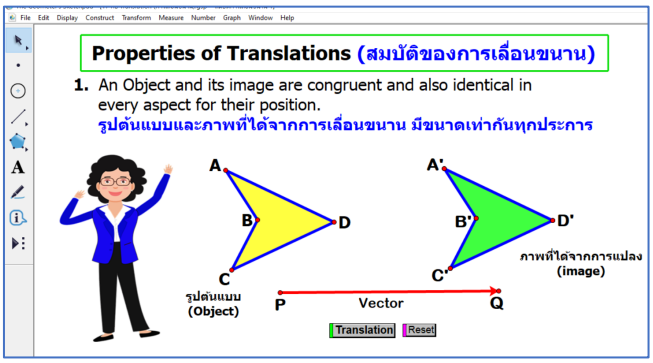
A **translation** is a transformation which moves all points on a plane through the same distance in the same direction. The direction and length of a translation can be illustrated in two ways:

- Translation arrows; and
- Ordered pairs.

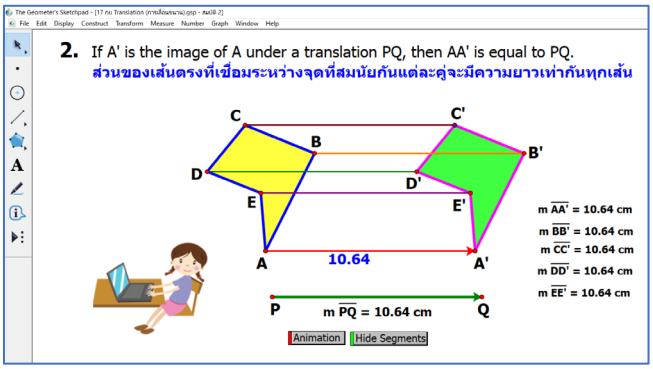


Properties of Translations:

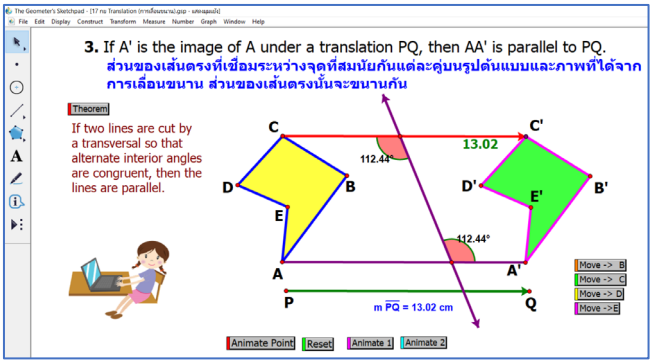
1. The original figure (an object) and its image are congruent and also identical in every aspect for their position.



2. If A' is the image of A under a translation PQ, then AA' is *equal* to PQ.



3. If A' is the image of A under a translation PQ, then AA' is *parallel* to PQ, BB′, CC′, DD′, and EE′.

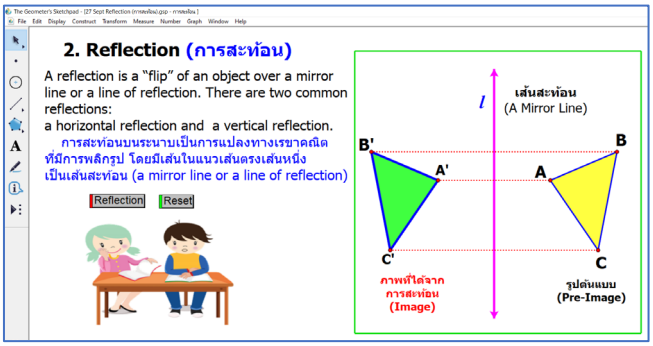


Students used a smartphone to explore the properties of translation of a figure ABCDE and its image A′B′C′D′ E′ by scanning this QR code .

Example 3: Online Learning Lesson on Reflection

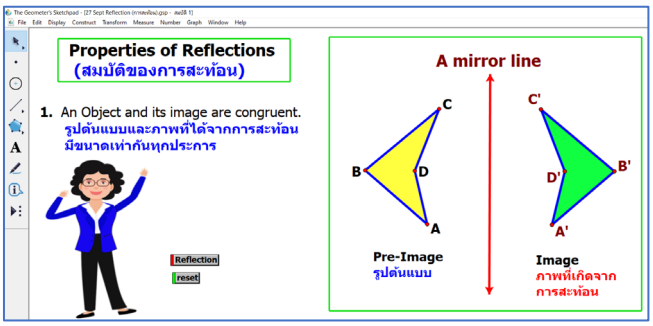
A reflection is a **flip** of an object over a line. There are two common reflections:

- *a horizontal reflection* and
- *a vertical reflection*.

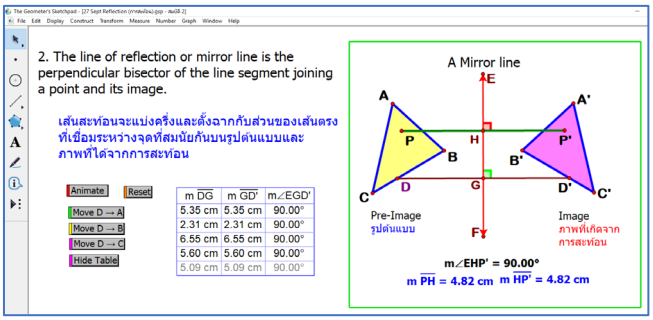


Properties of Reflections:

1. The original figure (an object or pre-image) and its image are congruent.



2. The line of reflection or a mirror line is the perpendicular bisector of the line segment joining a point and its image.



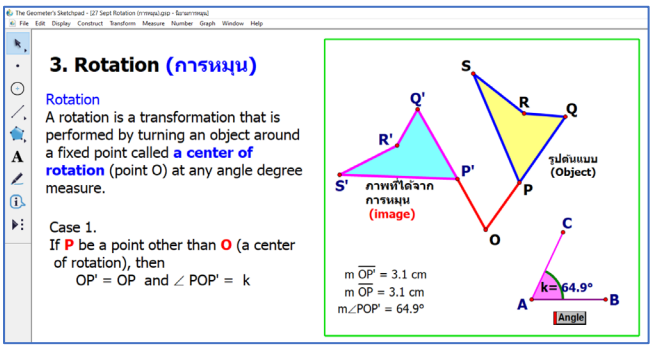
Students used a smartphone to explore the properties of reflection of a figure and its image by scanning this QR code .

Example 4: Online Learning Lesson on Rotation

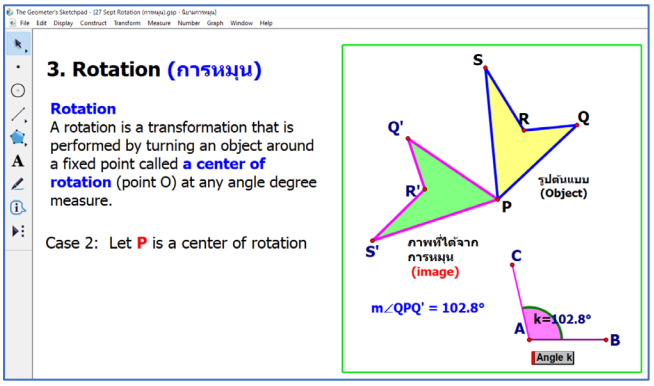
A *rotation* is a transformation that turns an object around a fixed point called a center of rotation at any angle degree. When describing a rotation, we have to state 3 things:

- Center of rotation;
- Angle;
- Direction, i.e. clockwise or counterclockwise of rotation.

(A rotation *counter-clockwise* is a *positive* angle, and *clockwise* is a *negative* angle.)



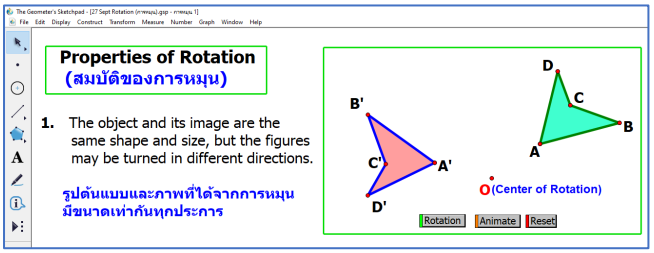
***Case 1*:**
Let ***P*** be a point other than O (a center of rotation)
All points rotate through ***k°*** clockwise/ counterclockwise about O. That is, if ***P'*** is the image of ***P*** under the rotation,
then ∠ POP' = ***k°***
and OP = OP'



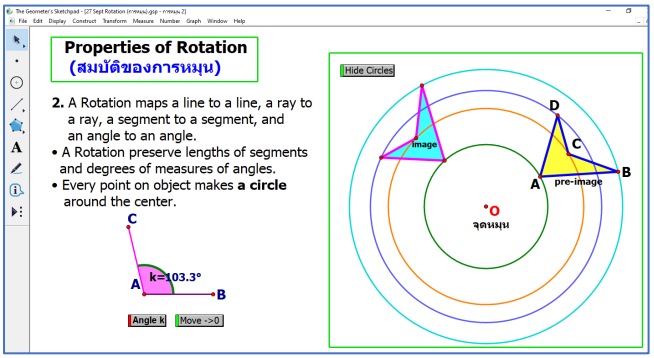
***Case 2*:**
Let ***P*** is a center of rotation.

Properties of Rotations:

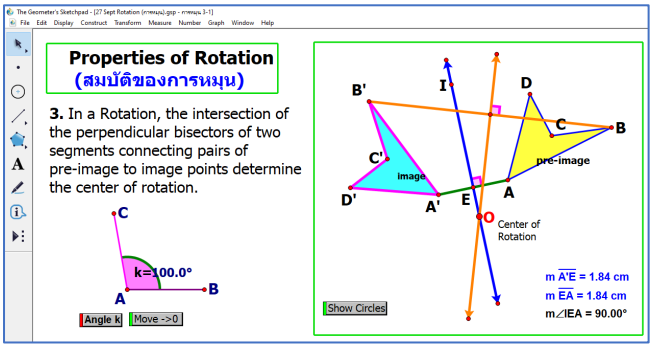
1. The object and its image are the same shape and size, but the figures may be turned in different directions.



2. A Rotation maps a line to a line, a ray to a ray, a segment to a segment, and an angle to an angle.
   - A Rotation preserves lengths of segments and degrees of measures of angles.
   - Every point on object makes a circle around the center.



3. In a Rotation, the intersection of the perpendicular bisectors of two segments connecting pairs of pre-image to image points determine the center of rotation.



Students used a smartphone to explore the properties of rotation of a figure ABCDE and its image A′B′C′D′ E′ by scanning this QR code.

Question 2: What are the students' perceptions on using online learning platform and self-study on transformations geometry incorporated with AR, and GSP?

Based on the interview, the researcher found out that the students in the sample revealed that they learned mathematics on transformations geometry from online learning platform incorporated with augmented reality. They used smartphone to scan QR Code Reader on the printed targets and the smartphone showed the animations of each steps of transformation. The students were able to interact with it. Augmented reality animated content of transformation geometry and it made the concepts easier to learn and retain. However, more than 50% of the students revealed that they wanted to study in the normal classroom, face-to-face interaction and used augmented reality in mathematics class.

7. Conclusions

The continuity in education, teaching and learning in mathematics during the COVID-19 in Thailand can be done because of the supports from all sectors such as Ministry of Education, Thailand, International College, Suan Sunandha Rajabhat University, teachers and students. The teachers developed contents and lessons on transformation geometry using AR and GSP effectively via online learning platform SSRUIC MOOC. The students had self-study through online learning lesson and used smart phone to scan QR Code Reader to explore the lesson. However, the researcher faced some technical issues during the data collection process. This is because an unexpected shift from face-to-face learning to online learning, there are few difficulties faced by students and teachers. The teaching and learning were not ready for online learning and many more factors. Many students were not able to use internet facilities at home. Computers and IT equipment at home are now in heavy demand from parents, and their children. The quality of mathematics education depends on access to internet, the right technology and required skills to use it. The researcher will conduct further study on the effects of using AR and GSP in teaching and learning mathematics in the future after the COVID-19 pandemic.

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