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THE EXPLORATION OF MATHEMATICAL OBJECTS IN ANIME SERIES REVIEWED FROM ONTO-SEMIOTIC APPROACH (OSA) THEORY

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Abstract

Mathematics is often associated with a boring subject in the classroom. There's a need for innovation, especially in the learning process, so students would not feel bored in learning mathematics. One of the innovations available is to connect mathematics with the student's interests. One of the things the students are interested in is animation works, especially anime series. This research aims to explore the mathematical objects in the anime series reviewed from the Onto-Semiotic Approach (OSA) theory. This research is descriptive exploratory research. Data were collected through observation of 5 anime series titles using a research instrument in the form of an observation sheet. The analysis process was carried out on the identified mathematical objects from the 5 anime series titles, then categorizing the identified mathematical objects according to the characteristics of the 6 categories of primary mathematical objects in OSA theory. The results indicate that there are 6 mathematical objects identified as the language category, such as the quadratic equation and trigonometry, 5 mathematical objects identified as the situation category, no mathematical object identified as the concept category, 1 mathematical object identified as the proposition category, 1 mathematical object identified as the procedure category, and 2 mathematical objects as the argument category. The result of this research can be used as an innovation in mathematics learning and as additional research on the use of popular culture in the classroom.
Keywords: Innovation, Mathematics Learning, Anime Series, Mathematical Objects, Onto-Semiotic Approach

Abstrak

Matematika kerap kali dikaitkan sebagai mata pelajaran yang membosankan di dalam kelas. Perlu adanya inovasi dalam proses pembelajaran agar siswa tidak merasa bosan dalam belajar matematika. Inovasi yang dapat dilakukan adalah menghubungkan matematika dengan sesuatu yang siswa gemari. Salah satu hal yang digemari siswa adalah karya animasi, khususnya serial anime. Penelitian ini bertujuan untuk mengeksplorasi objek matematika dalam serial anime ditinjau dari teori Onto-Semiotic Approach (OSA). Penelitian ini merupakan penelitian deskriptif eksploratif. Data dikumpulkan melalui observasi terhadap 5 judul serial anime menggunakan instrumen penelitian berupa lembar observasi. Proses analisis dilakukan pada objek matematika yang teridentifikasi dari 5 judul serial anime, kemudian objek matematika yang teridentifikasi dikategorikan sesuai dengan karakteristik dari 6 kategori objek matematika primer dalam teori OSA. Hasil dari penelitian ini menunjukkan bahwa terdapat 6 objek matematika yang teridentifikasi sebagai kategori language, antara lain bentuk persamaan kuadrat dan trigonometri, 5 objek matematika yang teridentifikasi sebagai kategori situation, antara lain permasalahan persamaan trigonometri dan manipulasi aljabar, tidak ada objek matematika yang teridentifikasi sebagai kategori concept, 1 objek matematika yang teridentifikasi sebagai kategori proposition, yaitu pernyataan tentang rumus luas permukaan dan volume bola, 1 objek matematika yang teridentifikasi sebagai kategori procedure, yaitu proses penyelesaian persamaan linear satu variabel, dan 2 objek matematika yang teridentifikasi sebagai kategori argument, yaitu jawaban dari permasalahan persamaan trigonometri dan rumus volume bola. Hasil dari penelitian ini dapat dimanfaatkan oleh guru sebagai inovasi dalam pembelajaran matematika, serta menambah penelitian tentang pemanfaatan budaya populer dalam pembelajaran di kelas.

Kata Kunci: Inovasi, Pembelajaran Matematika, Serial Anime, Objek Matematika, Onto-Semiotic Approach

INTRODUCTION

Mathematics is often associated with a boring subject in the classroom. According to Grootenboer & Marshman (2016:1), views of mathematics as a boring, dull, irrelevant, and inaccessible subject are pervasive across society and reinforced in the popular media. Also, mathematics is unattractive because it is static, abstract from nature or everyday life, and there are no experiments conducted (Abudula et al., 2012:101). Innovation is needed in the mathematics learning process so that the students wouldn't feel bored in learning mathematics. There are various kinds of innovations in the mathematics learning process in the classroom. One of the innovations available in mathematics learning is connecting mathematics with student's interests. Through this approach, the teachers and students can communicate about their interests, relate them to mathematics, and build student's interests to learn mathematics (Renninger et al., 2015:1-3).

One of the things that students like is animation work. Animated works are a medium that is recreational for students, apart from electronic games and social media. Among the animated works in the world, anime is the most popular. According to Kamus Besar Bahasa Indonesia, the meaning of the word "anime" is the animation work produced in Japan (Kamus Besar Bahasa Indonesia, 2016). The term "anime (アニメ)" itself appeared in Japan in the 1970s through the shortening of the word "animeshon (アニメション)," which is an uptake of the word "animation" (Napier, 2011:226). Japan Ministry of Economy, Trade, and Industry (METI) included anime as part of "Cool Japan," which is Japanese diplomacy strategy policies through popular culture and creative industries, including anime, manga, culinary, film, music, and others, involving the government and private corporation (Ministry of Economy Trade and Industry, 2015).

A report from The Association of Japanese Animation (AJA) shows that the distribution of anime outside Japan increased from 2002 to 2019. Figure 1 shows the distribution of countries in the world as the target of the anime market outside Japan. As seen in Figure 1, Indonesia is one of the targets among these countries (The Association of Japanese Animations, 2021). Also, the popularity of anime in Indonesia showed by the number of the subscriber on Muse Indonesia, one of the YouTube channel that distributes anime legally in Indonesia, that reached more than one million subscribers and still increasing (Muse Indonesia, 2020). Based on the explanation above, it means that anime is the most popular animation work in the world, including in Indonesia.

Figure 1. The distribution of countries in the world as the target of the anime market outside of Japan

Through the popularity of anime in Indonesia, the teachers can use anime series as a medium to attract students' interest to learn mathematics in the classroom. However, because anime is commercial work and only emphasizes the entertainment side, anime is not a medium that focuses on educational content, especially mathematics. It would be difficult for teachers to implement the anime series directly into mathematics learning without knowing what can be used from the anime series. Therefore, it is necessary to explore something that can be used in the anime series as learning material for the students in the classroom.

Abd Rahim et al. (2020:205) stated that anime has succeeded in attracting most people in the world. Sallehuddin & Omar (2011:16) also stated that students enjoy watching anime since it is fun and has many elements in it. But, some students may have aggressive behavior because of watching anime. This is likely because they are watching anime series that are not suitable for their age. According to MyAnimeList, which using the Motion Picture Association of America (MPAA) standard age rating system, anime has the age rating system PG (for kids below 13 years old), PG-13 (for teens from 13-17 years old), R (for young-adults above 17 years old), and G (for all ages) (Motion Picture Association of America, 2021; MyAnimeList, 2020). For example, the anime series “Naruto” has a PG-13 rating and the anime series “Tokyo Ghoul” has an R rating, but the viewers often come from the age below the standard. It will cause disturbances in their psychology because they watch shows that are not intended for their age so that aggressive behavior is born in them.

There are numerous anime-oriented researches done in the language aspect, either in Japanese or English. But, the research about anime in the field of mathematics is lacking.

According to Budianto (2015:180), research on anime is very lacking and still focused on Japan alone. It causes researchers outside of Japan who want to use anime as an object of scientific research to find it difficult due to language limitations. The most equivalent research is a research conducted by Beltrán-Pellicer, Medina, and Quero that was successful in utilizing a film titled "October Sky," which also has the same entertainment properties as anime, into mathematics learning in the classroom by implementing the mathematical objects identified in it (Beltrán-Pellicer, Medina, and Quero, 2018).

From the researcher's experience while watching more than 200 anime series titles, researchers often find mathematical objects that appear in one of the scenes in an anime series. One example is in the anime series "Sakurasou no Pet na Kanojo" in episode 5 which the mathematical object appears in the form of quadratic formulas, as seen in Figure 2. Therefore, the researcher wants to explore the anime series that contain mathematical objects in them, so that the teacher can take advantage of the anime series as student learning material to learn mathematics in the classroom.

Figure 2. The mathematical object appears in the anime series “Sakurasou no Pet na Kanojo”

Furthermore, according to Soedjadi (2000:13), there are 4 basic objects in mathematics, which are facts, concepts, relation-operations, and principles. Facts are conventions that express mathematical ideas in terms of symbols or words. Examples of facts are the symbol of numbers, points, integrals, and so on. Concepts are abstract ideas of the classification of an object. Examples of concepts are squares, functions, means, and so on. Relation-operations are the rules for connecting between one or more elements in mathematics. Examples of relations are addition, roots, logarithms, and so on. Principles are the relationship between two or more concepts by a relation. An example of a principle is a mathematical expression such as "the formula for the area of a circle is pi times the radius of the circle squared."

According to Godino et al. (2007:130), there are 6 categories of primary mathematical objects in the Onto-Semiotic Approach (OSA) theory that is used as the basis for construction by students, which are language, situation, concept, proposition, procedure, and argument. The language category is a term, statement, symbol, or image related to mathematics. For example, numbers, formulas, graphics, and so on. The situation category is mathematical problems, direct or indirect mathematical applications, mathematical exercises, and so on. For example, questions about solutions to linear equations, problems with the probability of an event, mathematical applications to build a building, and so on. The concept category is given through the definition or description of a concept in mathematics. For example, the definition of numbers, points, straight lines, means, functions, and so on. The proposition category is mathematical properties or attributes that express a concept in mathematics. For example, the statement "prime numbers are positive numbers more than 1 that only have exactly two factors, which are 1 and itself". The procedure category is operations, algorithms, or techniques in mathematics. For example, the process of determining the solution of quadratic equations, the combination and permutation of an event, integrating a function, and so on. The argument category is an answer as validation and explanation of a proposition or procedure. For example, the solution of a linear equation, the probability of an event, the value of a trigonometric function, and so on. Each category of primary mathematical objects in OSA theory collaborates and forms a configuration known as the configuration of the primary object, as seen in Figure 3 (Godino et al., 2009).

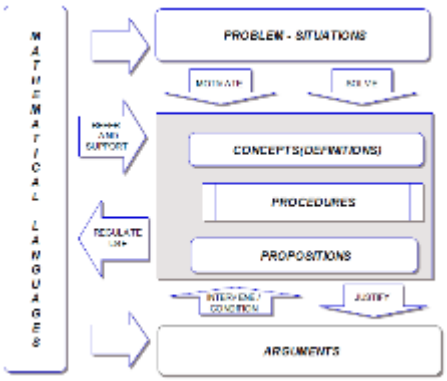

Figure 3. Configuration of the primary object

In the theory of the Onto-Semiotic Approach (OSA), mathematical objects and semiotic relationships are important parts of describing mathematical activities from an institutional or individual point of view (Font Moll et al., 2016; Godino, Batanero, and Font, 2007). Mathematics learning in the classroom always states that mathematics is an objective, certain, and correct science, and the representations of mathematical objectivity are mathematical objects themselves. It means that mathematical objects play an important role in the learning process of mathematics in the classroom in the instructional process by the teacher to help students construct these mathematical objects.

The results of the exploration of mathematical objects carried out in this study can pave the way for teachers to use anime series as a medium to build students' interest in mathematics. For example, teachers can take advantage of the anime series "Kobayashi-san Chi no Maid Dragon" through the mathematical problems that appeared in episode 9, as seen in Figure 4.

Figure 4. The problem appears in the anime series "Kobayashi-san Chi no Maid Dragon"

From the problems described above, the purpose of this study is to explore mathematical objects in the anime series reviewed from the Onto-Semiotic Approach (OSA) theory.

METHOD

This research is descriptive exploratory research. The data explored in this study were five anime series titles containing mathematical objects. Data obtained through the observation process using research instruments in the form of observation sheets arranged based on the aspects of the data to be observed, which are the title of the anime series, episode, period, and identified mathematical objects.

The observation process begins with identifying the title of the anime series that contains the mathematical objects in it. There are criteria for the anime series that will be used as research data:

1. Popular, indicated by the number of members on MyAnimeList over 100,000 members
2. Having a background story at school
3. Having mathematical object in it

If an identified anime series title meets all the above criteria, then the next step is synthesizing the fragment by cutting the parts of an episode at a certain period when mathematical objects are observed. There are five anime series titles collected during the observation process, namely:

1. Hyouka
   Genres: Mystery, School, Slice of Life
   Synopsis: Energy-conservative high school student Houtarou Oreki ends up with more than he bargained for when he signs up for the Classics Club at his sister's behest—especially when he realizes how deep-rooted the club's history really is. Begrudgingly, Oreki is dragged into an investigation concerning the 45-year-old mystery that surrounds the club room.
   Accompanied by his fellow club members, the knowledgeable Satoshi Fukube, the stern but benign Mayaka Ibara, and the ever-curious Eru Chitanda, Oreki must combat deadlines and lack of information with resourcefulness and hidden talent, in order to not only find the truth buried beneath the dust of works created years before them, but of other small side cases as well.
2. Yamada-kun to 7-nin no Majo (Yamada-kun and the Seven Witches)
   Genres: Harem, Mystery, Comedy, Supernatural, Romance, School, Shounen
   Synopsis: When Ryuu Yamada entered high school, he wanted to turn over a new leaf and lead a productive school life. That's why he chose to attend Suzaku High, where no one would know of his violent delinquent reputation. However, much to Ryuu's dismay, he is soon bored; now a second year, Ryuu has reverted to his old ways—lazy with abysmal grades and always getting into fights.
   One day, back from yet another office visit, Ryuu encounters Urara Shiraishi, a beautiful honors student. A misstep causes them both to tumble down the stairs, ending in an accidental kiss! The pair discover they can switch bodies with a kiss: an ability which will prove to be both convenient and troublesome.
   Learning of their new power, Toranosuke Miyamura, a student council officer and the single member of the Supernatural Studies Club, recruits them for the club. Soon joined by Miyabi Itou, an eccentric interested in all things supernatural, the group unearths the legend of the Seven Witches of Suzaku High, seven female students who have obtained different powers activated by a kiss. The Supernatural Studies Club embarks on its first quest: to find the identities of all the witches.
3. Mob Psycho 100
   Genres: Action, Slice of Life, Comedy, Supernatural
   Synopsis: Eighth-grader Shigeo "Mob" Kageyama has tapped into his inner wellspring of psychic prowess at a young age. But the power quickly proves to be a liability when he realizes the potential danger in his skills. Choosing to suppress his power, Mob's only present use for his ability is to impress his longtime crush, Tsubomi, who soon grows bored of the same tricks.
   In order to effectuate control on his skills, Mob enlists himself under the wing of Arataka Reigen, a con artist claiming to be a psychic, who exploits Mob's powers for pocket change. Now, exorcising evil spirits on command has become a part of Mob's daily, monotonous life. However, the psychic energy he

exerts is barely the tip of the iceberg; if his vast potential and unrestrained emotions run berserk, a cataclysmic event that would render him completely unrecognizable will be triggered. The progression toward Mob's explosion is rising and attempting to stop it is futile.

4. Boku wa Tomodachi ga Sukunai (I Don't Have Many Friends)
   Genres: Ecchi, Slice of Life, Comedy, Harem, Romance, School
   Synopsis: When Kodaka Hasegawa finds out that he will be transferring to a new school, he is determined to make a positive impression, and maybe even some friends. However, Kodaka discovers he is out of luck when he immediately gets labeled as a violent delinquent due to his blond hair and intimidating expression. Although a month has passed, Kodaka is still alone thanks to his notorious reputation. However, his life begins to change when he finds fellow loner Yozora Mikazuki talking to her imaginary friend in an empty classroom.
   After sharing stories of their lonely high school life, Kodaka and Yozora decide to overcome the difficulties of making friends together by starting the Neighbor's Club. Created for people who don't have friends, daily activities involve learning social skills and how to fit in, which will hopefully allow them to make friends. Joined by the eroge-loving Sena Kashiwazaki, and other eccentric outcasts, Kodaka may finally have managed to find people he can call friends, in this club filled with hilarious oddballs.
5. Zero no Tsukaima (The Familiar of Zero)
   Genres: Action, Adventure, Harem, Comedy, Magic, Romance, Ecchi, Fantasy, School
   Synopsis: Louise Françoise Le Blanc de La Vallière is a self-absorbed mage in a world of wands, cloaks, and royalty. Although she studies at Tristain Academy, a prestigious school for magicians, she has a major problem: Louise is unable to cast magic properly, earning her the nickname of "Louise the Zero" from her classmates.
   When the first-year students are required to perform a summoning ritual, Louise's summoning results in a catastrophic explosion! Everyone deems this to be yet another failure, but when the smoke clears, a boy named Saito Hiraga appears. Now Louise's familiar, Saito is treated as a slave, forced to clean her clothes and eat off the ground. But when an unfamiliar brand is found etched on Saito's hand from the summoning ritual, it is believed to be the mark of a powerful familiar named Gandalfr.

The next step is analyzing the fragments based on the analysis guidelines that have been prepared. After the analysis process is complete, the next step is to classify the results based on each identified primary mathematical object category. The final step is discussing the results of the analysis process, which is the number of mathematical objects identified in the anime series as well as mathematical objects in each category in OSA theory, as a conclusion of this study.

The analysis process uses guidelines arranged based on the characteristics of the 6 categories of primary mathematical objects in OSA theory. The following table presenting the characteristics of each category.

Table 1. The characteristics of the 6 categories of primary mathematical objects in OSA theory

Categories	Characteristics
Language	- Mathematical statements or sentences - Mathematical symbols or images - Mathematical representations in statements or sentences
Situation	- Mathematical problems or problems that could be solved through a mathematical process - Questions related to a concept in mathematics
Concept	- Definitive or conceptual explanations of a concept in mathematics
Proposition	- Statements related to a concept in mathematics
Procedure	- Processes of solving mathematical problems or questions related to a concept in mathematics
Argument	- Answers to questions or problems related to mathematical concepts

The analysis process is carried out by describing the identified mathematical objects in the fragment of anime series and then categorizing them according to the characteristics of the identified primary mathematical object categories, as presented in the following table.

Table 2. Categorization of the identified mathematical objects in anime series' fragment

No.	Mathematical Objects	Characteristics	Categories
1.	A mathematical statement or sentence that is said verbally in the fragment	Mathematical statements or sentences	Language
2.	A form of mathematical formula or notation that is shown visually in fragment	Mathematical symbols or images	Language
3.	A mathematical representation or analogy used in the sentence by the characters in the fragment	Mathematical representations in statements or sentences	Language
4.	A problem that requires the application of mathematical concepts in the fragment	Mathematical problems or problems that could be solved through a mathematical process	Situation

5.	A question related to a concept in mathematics given by the characters in the fragment	Questions related to a concept in mathematics	Situation
6.	A detailed explanation of a concept in mathematics by the characters in the fragment	Definitive or conceptual explanations of a concept in mathematics	Concept
7.	A statement about a concept in mathematics by the characters in the fragment	Statements related to a concept in mathematics	Proposition
8.	A process or steps to solve a question or problem in mathematics in the fragment	Processes of solving mathematical problems or questions related to a concept in mathematics	Procedure
9.	An answer to a mathematical question or problem in the fragment	Answers to questions or problems related to mathematical concepts	Argument

RESULT AND DISCUSSION

In the anime series "Hyouka" on episode 6 minutes 11:54 to 12:43, Chitanda tells Oreki about the reason for her anger. In her class, Mr. Orimichi, their math teacher, suddenly wrote a quadratic equation on the blackboard as seen in Figure 5, that is:

$$y = x^2 + x + 1\ (0 \le x \le 3) \qquad (1)$$

Then, Mr. Orimichi asked Kawasaki to draw equation (1), but he was confused and couldn't answer that question. Chitanda said Kawasaki's confusion was understandable because their class hadn't been taught about the domain of a function. The domain of a function that Chitanda refers to is the limit of the value of x in equation (1). Because Kawasaki couldn't answer the question, Mr. Orimichi was angry and then appointed Tamura, who has better skills in math, to answer it. Tamura also couldn't answer the question. Then Chitanda realized that Mr. Orimichi had wrongly remembered the material that should have been taught at that meeting.

Next, on episodes 13 minutes 10:47 to 11:38, there is a quiz held in celebration of the Kanya Festival. In the final round, the Host gives a question to the finalists. The question is "The formula for calculating the surface area of a sphere is $4\pi r^2$, then what is the formula for volume?" When the question was still not fully read, Shimizu had pressed the button to answer the question. After being given the opportunity by the Host, Shimizu's answer is:

$$\frac{4}{3}\pi r^3 \qquad (2)$$

The quiz committee stated that Shimizu's answer was correct, then the Host continued the part of the question and returned the correct answer.

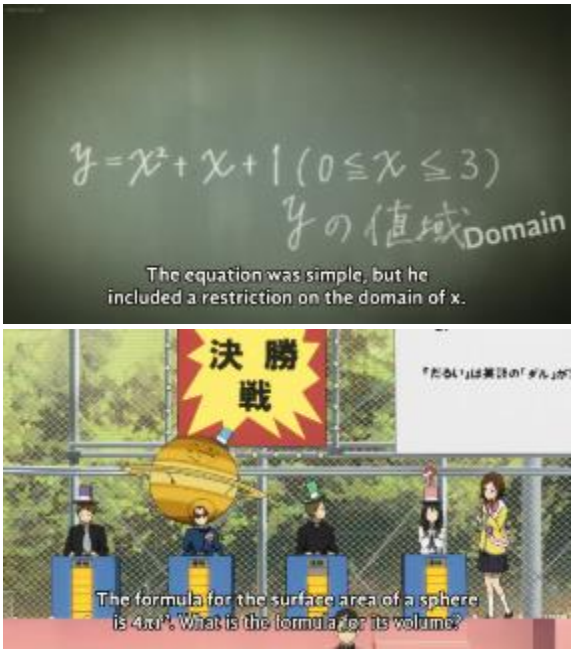

Figure 5. The identified mathematical objects in the anime series "Hyouka"

The following table shows the categories of the identified primary mathematical objects in this anime series.

Table 3. The identified primary mathematical objects in the anime series "Hyouka"

No.	Mathematical Objects	Characteristics	Categories
1.	Appear the form of a quadratic equation that Mr. Orimichi wrote on the blackboard, which is the equation (1).	Mathematical symbols or images	Language
2.	Appear the formula of the surface area and volume of a sphere by the Host and Shimizu.	Mathematical statements or sentences	Language
3.	Appear a question given by Mr. Orimichi related to the concept of quadratic equations and the domain of a function, which is the question about the graph of the equation (1) to students in the class, especially Kawasaki and Tamura.	Questions related to a concept in mathematics	Situation
4.	Appear a question given by Host to the finalists, which is "The formula for calculating the surface area of a sphere is $4\pi r^2$, then what is the formula for volume?"	Questions related to a concept in mathematics	Situation
5.	Appear a mathematical statement by the Host about the formula of the surface area of a sphere, which is "The formula for calculating the	Statements related to a concept in mathematics	Proposition

	surface area of a sphere is $4\pi r^2$."		
6.	Appear an answer from Shimizu to the question given by the Host, Which is the formula (2).	Answers to questions or problems related to mathematical concepts	Argument

In the anime series "Yamada-kun to 7-nin no Majo" on episodes 6 minutes 04:12 to 04:47, Yamada and his three other friends are undergoing a remedial class. Their teacher wrote a system of the trigonometric equations on the whiteboard, that is:

$$\begin{cases}\sin x + \sin y = 1\\ \cos x + \cos y = 0\end{cases}$$
$$\left(\frac{2}{\pi} \le x \le \pi, 0 \le y \le \frac{2}{\pi}\right) \quad (3)$$

However, there is an error in the limit for the value of x and y written by the teacher on the whiteboard as seen in Figure 6, with the correct value of x and y are:

$$\left(\frac{\pi}{2} \le x \le \pi, 0 \le y \le \frac{\pi}{2}\right) \quad (4)$$

Then the teacher asked Kameda about what formula to solve the question. With Yamada's help, Kameda managed to get it right. The teacher then asks one of the students to solve the equations. Yamada raised his hand and gave the following answer:

$$x = \frac{5\pi}{6}, y = \frac{\pi}{6} \quad (5)$$

Figure 6. The identified mathematical object in the anime series "Yamada-kun to 7-nin no Majo"

The following table shows the categories of the identified primary mathematical objects in this anime series.

Table 4. The identified primary mathematical objects in the anime series "Yamada-kun to 7-nin no Majo"

No.	Mathematical Objects	Characteristics	Categories
1.	Appear the form of a system of the trigonometric equation written by the teacher on the whiteboard, which is the equation (3).	Mathematical symbols or images	Language
2.	Appear a question given by the teacher related to the concept of the system of trigonometric equations, which is the question about the solution of the equations (3) for Yamada and his friends.	Questions related to a concept in mathematics	Situation
3.	Appear an answer given by Yamada, which is the equation (5) as the solution of the equation (3).	Answers to questions or problems related to mathematical concepts	Argument

In the anime series "Mob Psycho 100" on episode 1 minutes 12:05 to 12:20, the teacher in Shigeo's class wrote down the one-variable linear equation along with the solution process as shown in Figure 13, that is.

$$6x = 2x - 12$$
$$6x - 2x = 2x - 12 - 2x$$
$$4x = -12$$
$$x = -3 \quad (6)$$

Then the teacher asks another question that uses the same variable value as equation (17), that is.

$$x \div 6 = \frac{x}{6} = \ldots \quad (7)$$

The teacher tried to ask Shigeo, but he couldn't answer that question because he was asleep.

Figure 7. The identified mathematical object in the anime series "Mob Psycho 100"

The following table shows the categories of the identified primary mathematical objects in this anime series.

Table 5. The identified primary mathematical objects in the anime series "Mob Psycho 100"

No.	Mathematical Objects	Characteristics	Categories
1.	Appear the form of one-variable linear equations written by the teacher on the blackboard, which are the equations (6) and (7).	Mathematical symbols or images	Language
2.	Appear a question given by the teacher related to the concept of a one-variable linear equation, which is the question (7).	Questions related to a concept in mathematics	Situation
3.	Appear a process of solving a one-variable linear equation written by the teacher on the blackboard,	Processes of solving mathematical problems or questions related to a	Procedure

	which is the process (6).	concept in mathematics	

In the anime series "Boku wa Tomodachi ga Sukunai" on episodes 6 minutes 09:17 to 09:50, Kodaka, Kobato, Sena, Yozora, Yukimura, and Rika will go to a karaoke place. Kodaka and Kobato had just arrived at the place where they gathered, but Sena, Yozora, Yukimura, and Rika were already there. They gave Kodaka and Kobato a quiz before they left together. Yozora said that she came 5 minutes after Rika, then Yukimura said that she came 20 minutes earlier than Kodaka, next Rika said that she came 15 minutes earlier than Sena, and finally, Sena said that she had waited 5 minutes before Yukimura came. Kodaka then transferred the quiz to Kobato so that she guessed what time each of them had arrived, with the added hint that Kodaka and Kobato were coming at 12:50. On their way to the karaoke place, Kobato is still busy calculating the answer.

Figure 8. The identified mathematical object in the anime series “Boku wa Tomodachi ga Sukunai”

The following table shows the categories of the identified primary mathematical objects in this anime series.

Table 6. The identified primary mathematical objects in the anime series “Boku wa Tomodachi ga Sukunai”

No.	Mathematical Objects	Characteristics	Categories
1.	Appear the representation of a time sequence given by Sena, Yozora, Yukimura, and Rika to Kodaka and Kobato.	Mathematical representations in statements or sentences	Language
2.	Appear the problem given by Kodaka, Sena, Yozora, Yukimura, and Rika to Kobato that related to the concept of algebraic manipulation.	Mathematical problems or problems that could be solved through a mathematical process	Situation

In the anime series "Zero no Tsukaima" on episodes 3 minutes 03:09 to 03:31, Chevreuse explains the four elements of magic. The elements of magic are fire, water, earth, and wind. If they can masters different magic, it will become stronger. The level of a mage is determined by how many mastered magic elements, then Chevreuse asks a question about those levels. Montmorency raised her hand to answer the question. Her answer is "If you can combine two, it's Line, three elements called Triangle, and four elements called Square."

Figure 9. The identified mathematical object in the anime series “Zero no Tsukaima”

The following table shows the categories of the identified primary mathematical objects in this anime series.

Table 7. The identified primary mathematical objects in the anime series “Zero no Tsukaima”

Mathematical Objects	Characteristics	Categories
Appear the terms line, triangle, and square as a representation of the concept of geometry, which are the magic elements represented as the points and the mage levels represented as the shapes formed.	Mathematical representations in statements or sentences	Language

From the exploration result above, the following table presents the result of the identification of mathematical objects in the anime series.

Table 8. The result of the identification of mathematical objects in anime series

No.	Anime Series	Categories						Total
		(1)	(2)	(3)	(4)	(5)	(6)	
1.	Hyouka	2	2	0	1	0	1	6
2.	Yamada-kun to 7-nin no Majo	1	1	0	0	0	1	3
3.	Mob Psycho 100	1	1	0	0	1	0	3
4.	Boku wa Tomodachi ga Sukunai	1	1	0	0	0	0	2
5.	Zero no Tsukaima	1	0	0	0	0	0	1
	Total	6	5	0	1	1	2	15

NB:
(1): Language category
(2): Situation category
(3): Concept category
(4): Proposition category
(5): Procedure category
(6): Argument category

Based on the exploration result above, the categories of primary mathematical objects that have been identified in the anime series are:

1. The mathematical objects identified as the language category are the form of quadratic equations, surface area and spherical volume formulas, trigonometric equations, one-variable linear equations, algebraic representations, and geometric representations.
2. The mathematical objects identified as the situation category are the questions about quadratic equations, spherical volume formulas, systems of trigonometric equations, one-variable linear equations, and problems related to algebraic manipulation.
3. No mathematical object was identified as the concept category.
4. The mathematical object identified as the proposition category is the statement about the formula for the surface area and volume of a sphere.
5. The mathematical object identified as the procedure category is the process of the solution of a one-variable linear equation.
6. The mathematical objects identified as the argument category are the answers to the questions about the volume formula of a sphere and trigonometric equations.

The configuration of the primary object in Figure 3 shows that the mathematical language has the largest coverage area (Godino et al., 2009). The findings obtained in Table 8 following that theory, which shows that the language category is the most identified mathematical object. The language category is the easiest category to be identified in the fragments because the language category is the first object identified before other objects. According to Beltrán-Pellicer et al. (2018:21), identifying the language category could be verbally from sentences spoken by characters and non-verbally from symbols or mathematical forms depicted in a fragment, and the results of the exploration following this statement. In the anime series, the forms of equations and formulas appear non-verbally, and the mathematical statements uttered by the characters appear verbally. Also, the findings of Beltrán-Pellicer et al. (2018:22) show that concepts, procedures, and propositions do not appear clearly in the fragments because the film is produced without educational purposes. This is following the findings obtained in this exploration. The categories of concept, procedure, and proposition are the least identified in anime series because the nature of the anime series itself does not make education the main purpose.

According to Beltrán-Pellicer & Godino (2020:4), a problem given to the students will activate the affective aspects of the students, so that they can process the mathematical objects in it. From the exploration, the situation category identified in the anime series mostly appears in the form of mathematical questions, such as algebraic and trigonometric equations. Based on the statement before, applying the situation categories into mathematics learning is one of the solutions for encouraging the affective aspect from the students because this category contains mathematical problems in it.

By modifying the research conducted by Beltrán-Pellicer et al. and by changing the research object into anime series, the results obtained are similar to the findings obtained in previous research. In the anime series, there are identified mathematical objects in them. It means that there are many possibilities that the mathematical objects are scattered around the broad titles of anime series.

There are some variations in the mathematical concept identified from the fragments of the anime series. Some of them are high school materials such as quadratic and trigonometric equations, or middle school materials such as geometric representation and algebraic manipulation. The anime series that contain mathematical objects generally have a background story in the middle school or high school compared to elementary school, therefore the materials identified are in that level.

The identified mathematical objects in the anime series can be used in mathematics learning in the classroom. For example, the teachers can implement the system of trigonometric equation in the anime series "Yamada-kun to 7-nin no Majo" as a question on the subject of trigonometry. The teachers can also implement the context in the anime series "Zero no Tsukaima" as an alternative explanation on the subject of plane geometry. The other identified mathematical objects can also be implemented according to their needs and their role in mathematics learning in the classroom.

CONCLUSION

From the exploration, the conclusion of this study can be described as follows. There are 6 identified mathematical objects in the language category, such as the quadratic equation, the formula for surface area and the volume of a sphere, trigonometric equations, one-variable linear equations, algebraic representations, and geometric representations. There are 5 identified mathematical objects in the situation category, such as the questions about the quadratic equation, spherical volume formula, trigonometric equation, one-variable linear equation, and the problem related to algebraic manipulation. There is no identified mathematical object in the concept category. There is 1 identified mathematical object in the proposition category. The identified mathematical object is the statement about the formula for the surface area and volume of a sphere. There is 1 identified mathematical object in the procedure category. The identified

mathematical object is the process of the one-variable linear equation solution. There are 2 identified mathematical objects in the argument category. The identified mathematical objects are the answers to the questions about spherical volume formulas and trigonometric equations.

The results of this study can be used by the teacher as an innovation in mathematics learning in the classroom. We hope that there will be more innovations in mathematics learning in the classroom, either utilizing anime series or another popular culture so that students will no longer have difficulty and fear in undergoing the learning process. Further research on the exploration of mathematical objects in anime series is also needed because there are so many anime series titles that have the possibility of containing mathematical objects in them. We are aware of the limitations of the subject in this study so that through further research, we hope that other anime series titles can be explored and implemented in mathematics learning.

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