International Journal of Sciences: Basic and Applied Research (IJSBAR)

ISSN 2307-4531
(Print & Online)

http://gssrr.org/index.php?journal=JournalOfBasicAndApplied

The Digital Game's Impact on Student's Interaction Related to Sociomathematical Norms: A Systematic Literature Review

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Abstract

The use of digital games as learning mathematics media is ubiquitous. It comes in a variety of approaches, designs, and purposes. But, its impact on students' interactivity leads to a classroom social construct called sociomathematical norms is not revealed yet. Beside, technology use in education and traditional game use separately could raise students' sociomathematical norms. Although, sociomathematical norms are known as specific interactions among students and teachers which form mathematical concepts. This systematic literature review study, based on the PRISMA statement, conducted to collect critical information about the use of digital games' impact on students' sociomathematical norms. Articles which published between 2016 and 2020 in mathematics education field are screened. The findings show that the use of digital games raises students' sociomathematical norms if it is followed by an open ended learning approach and sharing feature. Otherwise, the norms cannot be detected explicitly. Future research related to this finding is also recommended.

Keywords: learning mathematics; digital game; student interaction; sociomathematical norms.

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1. Introduction

Consider mathematics as a product of human interaction, learning mathematics activities cannot be separated from teacher-student interaction [1, 2, 3, 4, 5]. The characteristic of mathematics which links the physical and mental world of humans [6] made it a little bit tricky to be taught. Any mathematical concepts cannot be taught to students directly as a phenomenon but as mathematician ideas through communication among them [8]. So, teachers as the representative of the mathematical community determine the mathematical quality of the classroom environment and norms established for mathematical aspects during students' learning activity [5]. Based on the emergent perspective, social and interactional aspects in learning mathematics can be detected by several norms known as sociomathematical norms [9]. Sociomathematical norms are "classrooms social constructs specific to mathematics that individuals negotiate in discussions to develop their personal understandings" [10, 15]. Sociomathematical norms involve negotiations between teachers and students in determining acceptable mathematical explanation criteria, different solutions, efficient solutions, sophisticated solutions, and an adequate mathematical diagram to the problems encountered [5, 11, 12]. It usually comes with common norms called social norms which indicate students' engagement in learning activities such as explaining their solution, conceiving others' explanations, justifying or arguing given solutions, and asking for clarification if needed. Differ from sociomathematical norms, social norms can emerge in any subject matter area, not only in mathematics [5]. To enhance these norms, cooperative learning is proposed. Students are placed in small groups so that they discuss given problems to solve [13]. It is intended for students to work together and take the advantage of the potential of each individual's uniqueness to achieve learning goals. Thus, the micro-culture that formed in cooperative learning is easier to intervene in order to approach conditions that allow a mathematical concept to be discovered and shared again with fellow class members [14]. Despite this, the teacher is the main role who elaborates those norms when students work actively with their mate to solve the given problem [10]. When the argumentation and justification made during learning are acceptable for both teacher and students, we consider that the norm is formed [9]. Students' own participation is needed. So, as a kind of rich learning environment, the game is used as an alternative media to convince students' engagement. As a learning activity by agreeing on certain rules to achieve the stated goals, games can preserve an interactive and competitive atmosphere during learning [15, 16, 17]. Using games as a part of learning activity has been worldwide and it comes in many ways [18]. Furthermore, games are known for its ability to provide a collaborative atmosphere among learners. Such a promising in the learning context [18, 19]. Meanwhile, the rapid change of the global education method has brought technology to improve learning activities. Thus, digital games are developed to provide better students' learning experiments and increase their competencies and skills [20]. As long as teachers around the world can connect to the internet or other devices, any qualified and visually interesting learning sources could easily be found [21, 22]. Former research shows that the use of technology could raise sociomathematical norms among students' through computer manipulations as communicative nonverbal [10]. Based on Hershkowitz and Schwarz published in 1999, students use computerized tools like spreadsheets, graphic calculators, and dynamic geometry software to solve the given problem and discuss mathematical concepts through the outcome displayed. Vice versa, the sociomathematical norms integrate the computational thinking and science [23]. On the other hand, digital game-based learning use effectively promoted the students' learning achievement, motivation of mathematics, self-efficacy, and interest

in learning mathematics [24, 25, 26, 27]. Even though the use of digital games got positive effects in learning mathematics, any information about its contribution to raising sociomathematical norms yet provided. This research aims to reveal recent studies involving the use of digital games and analyze whether they influence students' interaction indicating sociomathematical norms.

2. Method

This systematic literature review organized using the PRISMA flow chart [28]. The qualitative synthesis was chosen as its final step of data analysis to get an in-depth review specific to this issue. Considering the aim, study analysis and discussion based on a question: How does the digital game used in learning mathematics raise student's interaction refer to sociomathematical norms?

Specifically, articles are included if they fulfill some requirements. First, it was published between 2016 until 2020 in the mathematics education discipline. Selected articles hopefully represent the latest trend study in using digital games as learning mathematics media. Second, articles may come from quantitative, qualitative, or mixed method research approaches. Third, research samples or participant consist of students or both teachers and students. Samples or participants that focus on teacher perspective are excluded, due to bias-free. Fourth, the data reached if the research findings show any information about the student's interaction leads to sociomathematical norms. Finally, articles are searched by following keyword and Boolean operators below:

"learning mathematics" AND "digital game" OR "game" AND "technology" AND "interaction" OR "student interaction"

Based on the search results, there are 158 records identified through SpringerLink and 9 records identified through IEEE. The process of searching, screening, assessing, extracting, and synthesis of final articles were shown in Figure 1.

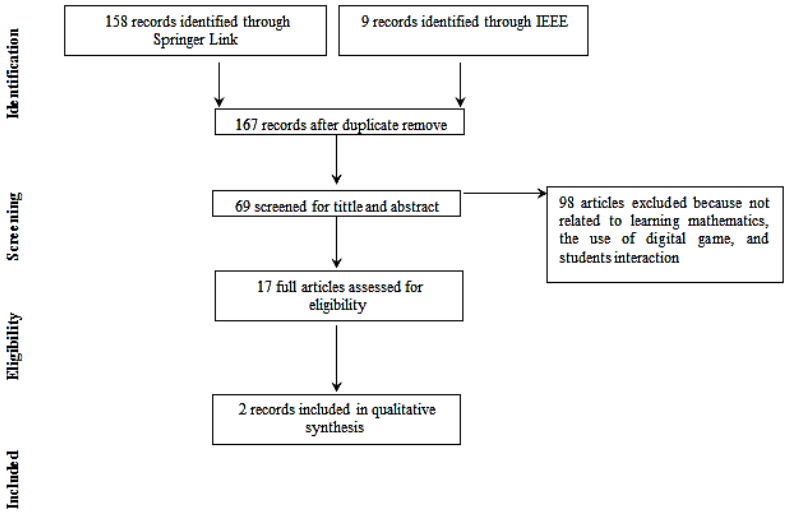

Figure 1: Flow diagram el watching data and extraction

Based on research purpose, researchers analyzed articles that related to the impact of the use of digital games in learning mathematics on student interaction. A full assessment of 17 articles before leads to just two articles selected. This was caused by student interaction referring to sociomathematical norms in other articles do not emerge clearly. Most of them reported positive outcomes in student engagement. Yet, the specific kind of engagement is not presented. When any article writes the specification of engagement skills used, it was commonly related to student social norms. Avoiding bias in the interpretation process, those are excluded.

3. Finding and Discussion

Students' responses related to sociomathematical norms are shown in Table 1. Both articles mention the emergence of sociomathematical norms during the learning process explicitly in different ways. The researchers then identified the impact of using digital games on student interaction according to sociomathematical norms.

Table 1: Review about selected studies

Sources	Students' responses	Digital Games' Impact refer to Sociomathematical Norms
(Bray & Tangney, 2016, p. 191).	● "... [after learning through digital games]I started thinking of shapes and everything you used to do in math … [in] different ways..." ● "You can have your own idea, even if the teacher is explaining it ... in a different way"	Working with digital games reshapes students' ways of thinking math. They even found different explanations compared to their teacher, but it is no longer the problem as long as they follow the given procedure. Whereas negotiating "different solution" is part of sociomathematical norms
(Hilton, 2018)	● "There's a lot of sharing [we can do using Airplay sharing feature]"(p.157) ● "[sharing feature made me easier to]...tell if my answers make sense"(p.163)	Special feature allows students to share their findings. Sharing is a common thing in learning mathematics. As sociomathematical norms proposed mathematical concepts ideally taken-shared to be.

The first article was conducted by [29]. This research lies on a complex foundation consisting of realistic mathematics education (RME), 21st-century skills learning models, and the use of technology. Each component is known as a learning approach and tool that enhances students' self-development [30, 31, 32, 33, 34, 35]. RME is known as an instruction theory for mathematics that presents mathematics as a human activity so that students are led to actively participated in the educational process and develop their own understanding of the

mathematical concepts they learn [30]. 21st-century skills and the use of technology, on the other hand, set learning characteristic that promotes students' collaboration, critical thinking, innovation, digital literacy, and life skills [35]. All of them provide students with a wide variety to cooperate and collaborate with their peers and teachers [35, 30]. It has a strong emphasis on increasing interactivity between students and teachers, whereas interactivity is necessary for establishing norms [36, 35, 37, 38]. Reference [29] explained how the combination of the RME approach, 21st-century skills, and the use of digital equipment developed structured learning activities. The students hopefully got a better learning experiment so that it influences their engagement and confidence. As a part of treatments, a digital game is involved not only for entertainment purposes but also helps students to learn mathematical concepts comprehensively. In this case, students asked to develop a new game with certain conditions based on a given game former. Through trial and error assisted by technology, students are directed to find a unique pattern that forms the game, thus modification on it helps students construct their insight about probability. The second article does not report on a series of treatments based on a specific framework, but a long period of programs implementing digital applications that are equipped with games in learning mathematics. Investigated by [39], the second article organized a survey to measure the influence of iPad use in learning mathematics on students' attitudes and engagement. It was a long period survey which took 2 years to collect the data. The participants of the survey were students from second to sixth-grader from a primary school located in a large urban area. This school implemented technology utilize in education i.e. iPad usage in learning mathematics. The iPad contains several features including math games. So, students learn mathematics assisted by iPad and teachers act as mentors and supervisors. In this survey, students asked to give their agreement or disagreement in five-point Likert-type items about the use of iPad during learning mathematics. At the end of the survey, a semi-structured interview was held to confirm the survey's findings. Ten students consisting of five boys and five girls are selected and were interviewed about their feelings and enjoyment when using the iPad in learning mathematics. Teachers also were asked about how their student's engagement, teaching strategies, and resources used in learning assisted by [39] result stated that math games made students do a lot of math tasks rather than conventional learning methods, without technological interference. Student's progress for each task then presented in a game-based application display. This feature can show the track of their work. It gives them a special personal experience, that learning is their individual improvement. Hence, students are no longer worried even if they have different outcomes from others, similar conditions reported by [29]. Using the iPad also helped students to share their work using the Airplay feature. Therefore, although students progressed individually, they could negotiate their findings with whole class members unexceptionally. Technology at this point has a significant influence on wide norms forming among students with more amount of students involved in the classroom constitution [40]. Apparently, both of the studies use a mixed method approach. In a mixed method approach, the qualitative findings could be supported by quantitative and conversely [41]. This supportive environment helps researchers obtain deep and rich findings regarding the research goal [42]. It also allows researchers to get a variety of data while involving digital games usually improve many aspects such as student learning outcomes, skills, and engagement [20]. However, both had different types of research designs and strategies due to each focus and scope. Looking deep into [29] work, digital games used in the research supported by open ended tasks help students to find "different solutions" or "different ways to interpret an object", so that having different views in learning is acceptable. Else, negotiating different solutions indicate the process of raising sociomathematical norms among students [5].

Having different ideas also helps some students to get more explanation by their partners. It raises students' possibility to compare their ideas as they have to do [2]. Thus, this learning approach provided students' occasion to constitute sociomathematical norms during learning. Step inside to Hilton's paper [39], using digital games equipped with communication features makes students easier to share their progress during learning. Students share their work with others and engage more in learning activities easily. While sociomathematical norms initiated "the development of individuals' reasoning and sense-making processes … [as a part] from their participation in the interactive constitution of taken-as-shared mathematical meanings" [5]. Besides, the use of technology supports student reflection on the learning process [43]. It helps students to develop individually, while at the same time progress classically. Both research show that digital games help students stay confident and state their own interpretation without apprehensive to be different from others. Students then easier to involve in negotiating their findings till the best choice of solution on their own preferences. Nonetheless, both researches shows different aspects of sociomathematical norms that emerge, but leads to the same conclusion that is the rise of possibility of sociomathematical norms existence.

4. Conclusion

The use of digital games in learning mathematics raises students' interaction related to sociomathematical norms. It is possibly caused by several conditions, such as the use of open ended approach and digital features provide students' accessibility to share their findings during the learning session. The open-ended approach assisted by technology helps students to autonomously construct their own interpretation of a mathematical concept, whereas games organize the rule of activity and interactivity. More possibilities of ways they can discuss are open. Dialogic circumstances enrich sociomathematical norms they constitute. Moreover, game-based display and Airplay, the sharing feature, facilitate students to share their progress during learning efficiently. A visual material to discuss can help them synchronize their work and their ideas. Nevertheless, the lack of such issues in others' findings cannot lead to the absence of students' sociomathematical norms.

5. Constraint

The data collected in this study stand on an assumption that sociomathematical norms occur as a part of students' interaction specific in negotiating mathematical concepts. While any studies excluded from the synthesis process, it cannot be concluded that students' interaction or student's own construct of mathematical meaning does not exist. The specific purpose of those studies may hide this aspect. But, the possibility of its occurrence still remains based on the improvement of students' learning outcomes.

6. Recommendation

This finding reports the conditions which enable students' interactions lead to sociomathematical norms. There are still possibilities to find other conditions considering positive improvement in learning mathematics using digital games. On the other hand, less information in this issue leads to poor concern about rising sociomathematical norms among students. Developing and implementing digital games to mathematics learning isn't supported by equal attention to sociomathematical norms. Thus, comprehensive research on developing

sociomathematical norms framework and assessment in using technology or digital games are recommended, regarding poor concern to this topic. While sociomathematical norms are the basic foundation to construct students' mathematical concepts in social culture [5, 2].

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