



Gamification of Science Learning: Perspectives on Constructing Student Creativity

Rindu Rahmatiah¹, Joni Rokhmat^{1,2}, A W Jufri^{1,3}, Gunawan^{1,2}, AA. Sukarso^{1,3}

¹ Doctoral Study Program in Science Education, Postgraduate Program of Mataram University, Indonesia.

² Physics Education Study Program, FKIP University of Mataram, Indonesia.

³ Biology Education Study Program, FKIP University of Mataram, Indonesia.

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Corresponding Author:

Rindu Rahmatiah

rindurahmatiah@gmail.com

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Abstract: One strategy to strengthen the profile of Pancasila students in an independent curriculum is through the creative dimension. Strengthening the creative dimension of the Pancasila Student Profile is related to the 21st Century Skills Framework formulated by the World Economic Forum. The framework outlines 16 important skills that children must have to be successful in the future, one of which is creativity. Unfortunately, Indonesia's creativity index is still ranked low compared to other countries. The Global Creativity Index (GCI) conducted by the Martin Prosperity Institute ranked Indonesia 115th out of 139 countries in 2015. As important learning for students, science learning must be responsive to this by facilitating the development of student creativity. Gamification is an effort to arouse interest, stimulate motivation, and encourage student involvement in learning. Much research has been conducted on gamification by adopting game mechanics and aesthetics for learning and generally succeeding in increasing student motivation and learning outcomes. However, the relationship between the use of gamification in learning and the development of student creativity has not been widely researched or discussed theoretically. Therefore, this paper tries to present a literature study regarding areas where gamification can be intervened so that it can develop and build student creativity.

Keywords: Creativity; Gamification; Science Learning.

Introduction

Awareness of the importance of teaching science should encourage education practitioners to continue trying to find ways to solve all the problems that exist in it. This article describes gamification as one of the solutions offered to solve problems that often arise in science learning. Current learning needs to focus on improving certain technical skills, new ways of thinking, and different learning approaches (McGrath, Naomi & Bayerlein, 2013). One approach that is in line with the characteristics of 21st century learning is gamification, namely game-based learning (Deterding, et. al., 2011). Gamification is a thinking game design technique and game mechanics to improve non-game contexts (Popkin, 2010). The use of game element design, game-play mechanics, aesthetics, and game thinking to be applied to non-game fields is carried out to motivate students

(Kapp, 2012). The idea of gamification is behind the logic that the motivational power of game elements can be transferred in educational contexts (Papadakis & Kalogiannakis, 2018). Thus, gamification in learning is the use of game mechanisms to enrich and facilitate learning.

Pancasila student profiles aim to answer a big question, which are students with profiles (competencies) that the Indonesian education system wants to develop (Kemdikbudristek, 2022). One of the dimensions of the Pancasila Student Profile is creativity. In KBBI, creative means having creative power; having the ability to create; is (contains) creative power. In short, creative is a noun or term/designation for someone who can create. Meanwhile, creativity in KBBI means the ability to create or inventiveness. This can be translated as creativity being a noun for something produced by people who can create. It is through these results

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(creativity) that can then be measured to find out the extent of a person's level of (creative) ability. Creativity is an essential skill that needs to be improved in learning (Trilling & Hood, 1999). Creativity shows skills in producing creative solutions to a problem (Eggen and Kauchak, 2001) thus, enabling innovative activities to be carried out (Sarooghi, et. al., 2015). In connection with patterns of thought and real action, creativity is a way of thinking and behaving in an original, creative, and new proportion (Cropley, 1999). The relationship between the use of gamification and the development of student creativity has not been widely discussed theoretically. Theoretical studies regarding areas that can be intervened by gamification so that they are involved in the development of student creativity are important things to review. Therefore, writing this article attempts to answer this.

Method

This article is the result of a literature review regarding gamification and student creativity. The initial steps in any research include finding, selecting, considering, and reading literature (Creswell, 2003). The literature review was carried out with the awareness that the knowledge and research carried out by people in the world continue to increase. The research topic, sample, and research area or field have been explored by other people before, and researchers can learn from things that have been done (Neuman, 2011). The main purpose of a literature review is twofold, namely: first, it is carried out to write a paper to introduce new studies on a particular topic that those involved in that scientific topic need to know; and second, relates to the interests of the research project itself, namely carried out to enrich insight into the research topic (Berg & Lune, 2009). Writing this literature review refers to the second objective. The literature in this article was found using the Publish or Perish search engine with the search areas "Scopus" and "Google Scholar". By using the words in the title "gamification creativity". From the list of articles that appear, articles that research in allied science fields are then selected and considered. Next, the articles are selected, read, and reviewed for studies that support the purpose of writing the article.

Result and Discussion

Gamification Intervenes in Aspects of Creativity Development

The transition from the industrial era to the information era, then now to the innovation era requires individuals to think differently and be able to connect things that seem unrelated to the goal of remaining competitive (Ritter, et. al., 2020). The picture of future

employment developments that are difficult to predict encourages educators to prepare the current generation of students with various skills. Content/material knowledge is no longer the only main prerequisite for work. Nowadays we need people who understand how to obtain, process, and then succeed creatively. Creativity is no longer seen as something that is "nice to have" but has become something that is a "must-have" (Ritter, et. al., 2020). On the other hand, creativity also enriches human life because it is heavily involved in the development of science and innovation (Feist & Gorman, 1998; Kaufman, 2002). Creativity facilitates problem-solving in everyday life and success in adapting to change (Cropley, 1990). To meet the demands of the 21st century, researchers and policymakers throughout the world emphasize that creativity must be possessed by all citizens of the world (Scholte, 2008).

The large role of creativity in an individual's life and development makes it an important skill in today's world (Alencar & Fleith, 2010; Hennessey & Amabile, 2010; Martinez, 2007; Simonton, 2006). One figure in the field of creativity who is often used as a reference is Torrance. Torrance (1977) defines creativity as the process of identifying problems, formulating ideas or hypotheses, testing and modifying hypotheses, and communicating the results. Creativity is the ability to produce new products or results that are new, innovative, unprecedented, interesting, beneficial to society (Campbell, 1960), and adapted to the context in which a person places himself (Lubart, 2007). Creativity refers to the ability that characterizes creative people (Guilford, 1970) to produce new compositions and ideas which can be imaginative or synthetic activities that involve forming patterns and combinations of past experiences that are connected to the present. Situation (Hurlock, 1978). Thus, it can be concluded that creativity is the ability a person has to discover and create something new, which is beneficial for oneself and the environment. A new thing does not have to be something that has never existed before. The element of novelty may have existed before, but by carrying out new combinations and constructions a different quality will be created from before.

Creative expression is often accompanied by feelings of satisfaction regarding personal accomplishment (Alencar & Fleith, 2010; Nakano & Wechsler, 2007). Creative individuals develop based on several theories, namely: psychoanalytic theory, humanistic theory, and Csikszentmihalyi theory (Masganti, et. al., 2016). First, psychoanalytic theory views creativity as the result of overcoming a problem that usually begins in childhood. Creative individuals are individuals who have certain experiences who are

then able to come up with ideas that can become innovative solutions to problems. Second, humanistic theory emphasizes creativity as a result of high-level psychology. Creativity can develop throughout life and is not limited to the first five years of life. Carl Rogers details three creative personal conditions, namely openness to experience, the ability to assess situations according to personal benchmarks, and the ability to experiment or 'play' with concepts. Third, Csikszentmihalyi's theory states that the first characteristic that facilitates the growth of creativity is genetic predisposition. For example, someone whose sensory system is sensitive to color is easier to become a painter and someone who is sensitive to tone is easier to become a musician. From these three theories, it can be seen that the seeds of creativity are present in every individual from an early age and will continue to develop throughout their life, influenced by various aspects.

Amabile (1996) suggests that there are three aspects that interact with each other to influence creativity, namely: cognitive, motivation, and social environment. Cognitive aspects are abilities related to a field. Cognitive can be knowledge, technical skills, talents, or expertise which is the main foundation for doing creative work such as solving-problems or carrying out assigned tasks. Motivation is the intrinsic and extrinsic reasons that direct individuals to engage in a task. The main motivation is intrinsic motivation, driven by deep interest, enjoyment (Amabile, 1996), curiosity, and a sense of challenge to be involved in a task. The social environment, such as family and school, plays an important role in supporting or inhibiting the development of creativity. Research shows that elements of the school context, such as the curriculum, management methods, evaluation methods, psychological climate in the classroom, teacher attitudes, and the relationship between teachers and students can facilitate or hinder the development of student creativity (Fleith & Alencar, 2008; Sternberg, 2010 ; Alencar & Fleith, 2010; Wechsler & Souza, 2011).

Turning to gamification, gamification is the adoption of game elements in a non-game context (Deterding, et. al., 2011). In this paper, the gamification of science learning referred to is the use of game elements in teaching science material so that students are motivated to "want" to learn. Gamification in learning focuses on efforts to influence students' psychological factors so that they can mediate learning outcomes (Kam & Umar, 2018). Lee & Hammer (2011) stated that the application of gamification can intervene in three main areas of the individual that is cognitive, emotional, and social. In the cognitive field, gamification provides a system of rules that students will learn

through active play and discovery experiences. Students' desire to be involved in the game indirectly makes them make efforts to learn. More broadly, games guide students to master material by engaging in potentially difficult tasks (Koster, 2004). Gamification makes it easier for students to understand learning, thereby increasing interest and motivation to learn further. This can oversee the development of students to become more creative and imaginative. The condition of students in exploring game elements and working together with their friends on certain themes is an important part of student development. Learning through games enables students to build the skills needed for academic understanding.

In the emotional field, gamification gives rise to various strong emotions, such as curiosity, frustration, and joy (Pramana, 2016), as well as optimism and pride (McGonigal, 2011). Gamification allows players (in this case students) to survive despite negative emotional experiences, and can even turn them into positive ones. An example of this emotional transformation is in the case of failure. In a game, there are certainly opportunities for players to win and lose, and experience success and failure. In fact, in many games, the only way to learn how to play is to experience failure over and over again so that students learn all the time (Gee, 2008). Students are encouraged to proactively try new methods because they can repeat assignments without fear of failure. In time, students will learn to view failure as an opportunity, rather than becoming afraid, helpless, or overwhelmed (Lee & Hammer, 2011). In addition, gamification can shorten feedback cycles and create an environment that rewards student learning efforts. This is different from ordinary learning where there is a high risk of failure and a long feedback cycle so that students experience anxiety, not anticipation (Pope, 2003). From gamification, students learn to see failure as an opportunity to continue to succeed, not a reason to give up (McGrath & Bayerlein, 2013). In this way, gamification offers resilience in the face of failure, by reframing failure as an important part of learning.

Furthermore, in the social field, gamification allows students to try on new identities and roles and make decisions from their new perspective (Squire, 2006; Gee, 2008). Players can assume or adopt new roles, exploring new sides in a safe play space. Games can provide social credibility and recognition of academic achievements, which may be invisible or even devalued by other students (Lee & Hammer, 2011). Gamification can also provide a learning environment that is constructive and socially interactive (Chan, et. al., 2017) as well as safe and real for students to experiment without danger (Kim, et. al., 2009). Students who are active in a gamified learning environment will be more receptive and willing to

engage in similar learning in the future (Papadakis & Kalogiannakis, 2018). Therefore, learning in a gamification environment is considered capable of overcoming various problems and difficulties in teaching science.

From a literature review regarding creativity and gamification, the author found a relationship between the results of Amabile (1996) and Lee & Hammer (2011). The three aspects in the development of creativity according to Amabile (1996) which were explained at the beginning apparently correspond to the three main areas in that gamification can intervene according to Lee & Hammer (2011). The main areas intervened by gamification according to Lee & Hammer (2011), namely the cognitive, emotional, and social of the individual, intersect with aspects that influence creativity, namely cognitive, motivation, and social environment according to Amabile (1996). First, in the cognitive field. Gamification provides students with (cognitive) knowledge gradually until they reach mastery and the ability to engage in potentially difficult tasks. This cognitive aspect (knowledge) is the main foundation for students to be involved in learning and is also the main prerequisite for developing creativity. One way is through students' efforts to solve the problems they encounter. This is related to flow theory. Flow occurs when students engage in an activity (physical, mental, or both) in such a way that they forget time and the outside world (Mirvis & Csikszentmihalyi, 1991). Students try to improve mastery of the material with the aim of maintaining a flow of satisfaction. This is what every teacher hopes for in learning.

Second, in the emotional field. Gamification creates various opportunities for the formation of student emotions, including positive emotions and negative emotions. Emotions can influence students' behavior, thoughts, feelings, hopes, and aspirations. When students are in a gamification environment, cognitive engagement refers to the focus of the student's attention in learning, while emotional engagement refers to the role of emotions in supporting desired cognitive processes. This emotion itself is closely related to motivation. Emotions and motivation are an individual's psychological state. From a health perspective, the application of gamification in learning will increase dopamine levels in students' bodies, causing a natural increase in attention and motivation (López-Jiménez, et. al., 2021). Dopamine, which is a hormone that produces self-satisfaction, is released every time a student responds correctly and receives an award (Willis, 2011). During gamification, students can be actively involved in the game and receive direct feedback on learning. Through this feedback, students know their level of progress in learning and guide them to correct mistakes.

Apart from that, gamification also creates positive experiences around learning because games have great potential to provoke and develop students' positive emotions such as curiosity, optimism, pride, and security. This will synergize with the emergence of student motivation which causes students to be involved in the game and persist in playing it (Bzuneck, 2004).

According to sociocognitive theory (Ryan & Deci, 2000), motivation is one aspect of developing creativity, resulting from the interaction of personal characteristics and social context. Third, related to the social sector. Gamification supports students to explore new sides of the safe play space, which may be invisible or even looked down upon by other students. The social environment such as friends, teachers, and school is also an aspect that influences creativity. Apart from that, choosing the right learning strategy also plays a very important role in developing student creativity. Therefore, the teacher's role in this case is considered very important to build students' emotional conditions and motivation to remain enthusiastic in learning, as well as developing their creativity.

The integration of gamification in learning can increase engagement, excitement, and motivation to support relevant activities that contribute to science education (Loganathan, et. al., 2019). Several theories underlying gamification are self-determination theory, goal-setting theory, and flow theory (Kalogiannakis, et. al., 2021). First, self-determination theory suggests the basic psychological needs of all individuals, namely relatedness, autonomy, and competence. These three basic needs are interconnected and influence intrinsic motivation (acting because of interest and attraction) and extrinsic motivation (acting because of reward). Second, goal-setting theory reveals that goals that are straightforward, specific, reasonable, and not too difficult can effectively increase individual performance and engagement (Landers, 2014). There are four factors that link goals with individual performance, namely: individual commitment to goals, feedback received, complexity of activities carried out, and situational constraints related to the task. Third, flow theory describes that an optimal psychological and psychological state can maximize an individual's enjoyment and involvement in something. This flow theory emphasizes internal processes and experiences that are closely correlated with intrinsic motivation.

Regarding the theory underlying gamification, creativity is related to self-determination theory and flow theory. Self-determination theory is one of the most popular foundations for explaining student engagement in the gamification of science learning. Gamification causes student involvement in games so that students can gain knowledge to enrich their cognitive aspects,

and without realizing it, students also develop one of the most important aspects of creativity. Much of a student's engagement in learning can occur through a state of "flow" (flow theory). Involvement in gamification activities makes students practice solving problems in various ways and finding various solutions so that it can lead to the discovery of new methods of dealing with problems. Well-gamified learning materials will encourage a state of "flow", so students will spend more time and more effort. Students will gain rich experience in playing while learning, which will ultimately lead to increased creativity because the "knowledge base" is one of the criteria for someone to be creative (Kalinauskas, 2014).

Self-determination theory shows the existence of two forms of motivation, namely intrinsic motivation and extrinsic motivation. Intrinsically motivated individuals will engage in gamification because they find it interesting, challenging, and rewarding. Meanwhile, extrinsic motivation allows individuals to engage in gamification for external reasons such as getting rewards, social recognition, or avoiding punishment (Amabile, et. al., 1994; Guimarães, 2004). Intrinsic and extrinsic motivation can lead to improved performance, but only intrinsic motivation is directly related to improved mental health, creativity, learning outcomes, and lasting engagement in an activity (Ryan and Deci, 2000). Several studies show the positive influence of intrinsic motivation on the expression of creativity (Amabile, 1989, 2001; Collins & Amabile, 1999; Fleith & Alencar, 2010; Hennessey, 2006; Sternberg, 2006) and extrinsic motivation which can also support the development of creativity (Amabile & Pillemer, 2012; Eisenberger & Shanock, 2003). The use of Information and Communication Technology (ICT) supported by gamification contributes to increasing learning motivation, as well as increasing attention and concentration in class. Additionally, teachers state that technology and gamification stimulate children's creativity and the development of cooperation and problem-solving, which strengthens independent learning (Ricoy, et. al., 2022). Based on the literature review that has been presented, in theory, it can be said that gamification in science learning is able to develop and build student creativity.

Creative Disposition Related to Gamification

Creativity not only includes skills but also includes disposition/character. A creative person certainly has a creative mind and a creative character (disposition). There is also literature on dispositions that calls dispositions habits of mind or "thinking habits". There are five creative dispositions, namely curiosity, persistent, imaginative, collaborative, and disciplined behavior (Lucas, 2016; Lucas, et. al., 2013). These five

creative dispositions are characteristics that exist in a creative person and can be used as a reference in developing gamification of science learning. The gamification that will be developed must train these five creative dispositions to build student creativity.

First, curiosity (inquisitive). Curiosity is the desire to find out, learn, and ask questions about new information or knowledge (McEllmeel, 2002; Renner, 2006). Curiosity motivates students to take action in exploration (Schmitt & Lahroodi, 2008; Litman & Spielberg, 2005), research, or simply experiment. This is done by students as a response to assumptions, conditions, and critical thinking about existing situations or things. Gamification can practice this by exposing students to contextual problems in learning. Gamification can present content in the form of images, videos, and game questions that stimulate their curiosity and curiosity further. Jones & Flint (2013) state that curiosity is a powerful catalyst or stimulant for human creativity, discovery, and learning. This will make students actively make efforts to fulfill and answer questions arising from their curiosity, one of which is by making "learning" efforts and exploring various learning sources. This behavior is also related to the "flow" theory, where students who are in a state of flow will learn happily. Gamification encourages students to always learn, satisfies curiosity and self-satisfaction (Smith-Robbins, 2011), and creates feelings of joy in learning while playing (Cankaya, et. al., 2010). Thus, gamification can open up opportunities for students to learn "voluntarily" out of desire and for their satisfaction.

Second, never give up (persistent). The character of never giving up is reflected in real actions to keep trying and not just give up when facing difficulties. This character is also reflected in the behavior of daring to take risks to be different from others. In everything, there is uncertainty so the character of never giving up will view uncertainty as an opportunity. In gamification, there are various forms of learning games that consist of various levels or levels of difficulty. As with any serious game, in the game, there is definitely a chance of failure. Through the failures encountered, students will learn all the time (Gee, 2008). This condition of experience in the form of failure will directly train the character of never giving up in students. In time, students will learn to view failure as an opportunity to continue to succeed, not a reason to give up (McGrath & Bayerlein, 2013), become afraid, or be helpless (Lee & Hammer, 2011). Gamification makes students enjoy experiences and overcome challenges (Ong, et. al., 2013). Thus, gamification can be a means to train resilience in the face of failure, thus forming a character of never giving up.

Third, be imaginative. Imaginative character is being able to think about various possibilities, being able to relate one thing to another, and using intuition (Lucas, 2016; Lucas, et. al., 2013). Imaginative character begins with the emergence of a curious character. Zuss (2008) states that curiosity is important as a driver involved in helping create new connections between ideas, perceptions, concepts, and representations. High curiosity about something will encourage the emergence of various thoughts so that it will give birth to various imaginations about that thing. Gamification prepares students with several alternative solutions to the problems they encounter (Wilson, et. al, 2016) and builds students' skills through each level of the game (Prambayun, et. al., 2016). Gamification which contains content in the form of images, videos, or questions through games will stimulate students' imaginative character to develop further.

Fourth, collaborative. These characteristics include: being able to share with others, giving and receiving input, and collaborating well with others. In gamification, there is a challenge element that can be done individually or in groups (team challenge). One of the important game designs is to provide concrete challenges that are specific, difficult enough, and motivating for students (Locke, 1991; Bandura, 1986). To complete group challenges, students will learn together, give and receive input from each other, and work together to determine a strategy to win the game. Gamification involves students in a friendly competitive environment (Papastergiou, 2009) and provides students with experience through the process of mastery and involvement in difficult situations (Kiili, 2014). Therefore, challenges for groups can facilitate the development of students' collaborative character.

Fifth, behave in a controlled manner (disciplined). This character includes developing skills in certain techniques, reflecting critically on himself, making things, and trying to improve them. The character of controlled behavior is related to the character of never giving up in the face of failure or difficulty. When students experience failure or encounter difficulties in gamification, students who have the character of never giving up will automatically look for other ways to respond to this failure. Students will critically reflect on themselves, question various possible causes of failure, and try and find ways to correct these mistakes. Students will continue to do this until they find a way to victory and get prizes in the games they participate in. Kivetz, et. al. (2006) stated that individuals will make more efforts to obtain rewards. Gamification can improve learning attitudes in developing students' cognitive, motor, and skill abilities (Felicia, 2009). Thus,

gamification can train students' controlled behavioral characteristics.

Creativity can be an innate characteristic of a student, but can also be enhanced through various means in the classroom (Park & Seung, 2008). To obtain results that can build creativity, the application of gamification must facilitate a creative disposition in the learning process. Games are designed to develop and test various meta-cognitive strategies (Kim, et. al., 2009). Through well-designed rules and mechanisms, students can develop cognitive strategies to win the game. A game not only allows the construction of factual, conceptual, procedural, or meta-cognitive knowledge but also improves comprehension, application, analysis, synthesis, and evaluation skills (Krathwohl, 2002). Gamification will produce a series of emotional signals from students towards phenomena differently thereby improving the way they internalize or respond to situations, thereby ultimately building their creativity.

Gamification is considered able to answer students' needs because according to studies, visuals are processed more quickly by the human brain compared to text. The main contribution of gamification to children's learning is increasing motivation that prioritizes creativity, problem-solving skills, and cooperation (Amabile, 1989, 2001; Collins & Amabile, 1999; Fleith & Alencar, 2010; Hennessey, 2006; Sternberg, 2006). The use of mechanisms, dynamics, and game components in learning can stimulate children to encourage their learning (Kapp, 2012). Having a sense of satisfaction and achievement in learning will increase students' capacity to solve problems thereby increasing creativity, independence, and motivation to learn (Ricoy, et. al., 2022). Gamification can be developed and supported by technology. The use of information and computer technology (ICT) in teaching and learning activities contributes significantly to student creativity and motivation (Borges and Fleith, 2018; Antonenko & Thompson, 2011; Barak et al., 2011). Thus, applying gamification in learning will make the learning atmosphere more enjoyable, encourage students to complete their learning activities, help students focus more and understand the material being studied, and allow students to compete, explore, excel in class, and develop their creativity.

Conclusion

Gamification functions as a facilitator that can "lure" students to want to learn by giving those challenges that are relatively safe, interesting, and gradual until they achieve learning goals. Based on a literature review, gamification can build creativity based on two ideas. First, through the areas that gamification

can intervene in, which are aspects that influence the development of student creativity, namely cognitive, motivational, and social aspects. Second, creativity is inherent in the theories that underlie gamification itself, namely goal-setting theory and "flow" theory which allows students to be immersed in a state of play while learning to maximize student involvement in the gamification environment, which without realizing it will train and develop their creativity. The application of gamification must be supported by appropriate learning strategies, where the teacher as a facilitator must facilitate the development of students' creative disposition factors, such as curiosity, persistence, imagination, collaboration, and behavior. Controlled (disciplined) through the game elements adopted. Gamification will produce a series of students' emotional cues towards phenomena differently thereby improving the way they internalize or respond to situations. In the end, gamification is just an alternative to "doing something" that seeks to develop student creativity. This state of being immersed in learning while playing environment or a state of "flow" can facilitate the development of student creativity. This literature review has revealed several domains that support gamification of learning that can be carried out as an effort to build student creativity.

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Author Contributions

First author: writing research articles. Second and third authors: review and direct the substance of the article. Forth, and fifth author: checking the draft research article. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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