The Analogy Game

How can a tabletop game be used to improve players' understanding of analogies and lead to improved analogies for learning?

Abstract

Analogical thinking is a deep part of how we make sense of the world in our daily lives and has been widely studied for educational purposes. Encouraging learners to generate their own analogies and discussing them with peers can have a positive impact on learning. However, studies into analogies do not consider students' understanding of analogies, or their analogy-making skills. No real guidelines or training methods exist for making analogies. This research uses an iterative design process to explore how a tabletop game can be used to develop the knowledge and skills that are needed to make use of analogies effectively. The results indicate that players perceive their own understanding of analogies and the quality of their analogies to have improved throughout the game. An analysis of the analogies made by players before and after the game, however, does not indicate any improvement of the quality of the analogies. This could be due to the framework that was used. Nonetheless, the game shows a positive impact on the players in general.

Contents

I. Introduction

1.1. Background and motivation

In our everyday lives, analogies and metaphors structure the way we think and understand the world around us (Lakoff, 1980). They play an important role in how we come to experience the world and how we make sense of unfamiliar things. We do this by relating them to experiences that *are* familiar to us. In this process, structural and relational similarities between the familiar and unfamiliar concepts are mapped out in comparisons to one another, to create an analogy (Seel, n.d.) (Gentner, 1983). This is done as follows: A :: B as C :: D, e.g. gills in fish are as lungs in mammals.

These types of comparisons require numerous cognitive processes that are crucial for higher order thinking, problem solving, learning, and reasoning (Godden & Grey, 2021; Richland & Simms, 2015a). Since analogies help to plain complex concepts in simple and concrete terms, they are often used as educational tools. Gray and Holyoak discuss the positive impact of analogies when teaching STEM subjects (Gray & Holyoak, 2021). Blanchette and Dunbar talk about the production paradigm, as opposed to the reception paradigm which argues that individuals who create their own analogies had better learning outcomes than those who received ready-made analogies (Blanchette & Dunbar, 2000). When receiving analogies passively, students tended to focus more on surface similarities and thus only touched on superficial knowledge, while student creating their own analogies remembered concepts better. This is probably due to deeper engagement with the topic, as students spend more time thinking about the structure and relationships.

However, these studies do not address the process of making analogies itself, nor to what extent students struggle to understand or make analogies. Without the proper knowledge about analogies and dedicated training in making analogies, students cannot fully benefit from learning via analogies, as their mind is occupied with understanding the medium of analogies, as well as processing information about the new subject.

1.2. Approach

This research is based on a human-centred design where qualitative methods, such as interviews, and questionnaires with participants will give insight into what skills and behaviours need to be developed in order to improve understanding and self-generation of analogies. Based on these findings, a serious game is designed, as the medium of a game is effective at developing skills and behaviours in a playful setting (Viudes-Carbonell et al., 2021). This research is based on an iterative design process which allows to balance game elements with learning objectives. This process will be discussed under *Methodologies*.

1.3. Research Question and Design Goals

This research attempts to design a tabletop game that improves players' structural understanding of analogies and thereby improve their analogy-making skills. The design goal of this research is to investigate *how* game mechanics can be designed to lead to desired learning outcomes and will be evaluated via observed dynamics and aesthetics from the MDA+ framework which will be explained under *Methodologies* (Hoogendoorn, 2021).

The research question asks whether an improvement of analogy-making skills can be facilitated via a tabletop game. This impact will be measured via (1) players 'self-evaluation on their understanding of analogies before and after the game, (2) the self-perceived quality of their own analogies and (3) a framework that evaluates analogical reasoning.

II. Theoretical background

2.1. Analogies

Analogies are comparisons between two different concepts or ideas, that focus on relations and structures between these ideas, rather than their attributes or features (Gentner, 1983). Analogies are very close to metaphors, because both create comparisons to make the idea more tangible to the listener. Metaphorical comparisons can go beyond the literal truth of a sentence and use figurative language (Haglund, 2013). For example, “Drug abuse is like swimming in a whirlpool: the deeper you dive into it, the more you will get sucked into it” is more metaphorical, as drug abusers are not physically being pulled in any way. Therefore, the terms metaphor and analogy are often used interchangeably and will therefore also be treated as such in this research.

The main purpose of analogies is usually to explain a complex or abstract concept or process, using simpler or more familiar ones. Much research supports the positive impact of analogies on learning objectives, as it facilitates knowledge transfer and divergent thinking (Clement & John, 2008; Coll et al., 2005; Niebert et al., 2012). However, what plays an important role in learning via analogies is the prior knowledge that learners have which needs to be tapped into. Niebert explains that, often, teachers fail to fully understand what kind of knowledge and experiences their students can actually relate to and therefore create analogies that fall flat. He highlights the importance of experiential learning which is grounded on embodied experiences of the learners, explaining that analogies should be based on experiences that are physical, simple and concrete (Niebert et al., 2012).

2.2. Analogies and Constructivism

Constructivism argues that knowledge is not a fixed set of information but rather, constructed, as learners interact with their environment. Learning occurs, when subjects embed new concepts into their current world view, seek solutions to problems and engage in constructive social exchanges (Anderson, 2008; Savin-Baden et al., 2004).

As such, self-generated analogies are compatible with constructivist learning, as it takes place in an interactive, situated context, where learners can engage in discussions with others. This learning environment is what Vygotsky refers to as *zone of proximal learning*, where learners are challenged to learn at the edge of what they are familiar with (Vygotsky, 1978). Analogies offer learners a stimulating challenge to explore how they can use their own prior knowledge to process new information and thereby lead to improved learning outcomes. Such an approach also facilitates knowledge transfer (Gray & Holyoak, 2021; Haglund, 2013). This way of using analogies has been proven to be an effective educational learning tool by numerous studies that focused on learning chemical models, using analogies as heuristic tools for hypothesis testing and for learning STEM subjects (Aragón et al., 2014; Duit et al., 2001; Gray & Holyoak, 2021).

2.3. Analogies and Self Determination Theory

Self-Determination Theory argues that learners who experience autonomous motivation, i.e. intrinsic motivation, or extrinsic motivation that aligns with their value and sense of self, experience better performances and are persistent with regards to learning (Deci & Ryan, 2008). This aligns with current research around self-generated analogies, as opposed to learning with ready-made analogies. Crucial to self-determination theory is also the fulfilment of competence, autonomy, and relatedness to ensure optimal functioning (Deci & Ryan, 2008; Patall et al., 2019). These three anchors are also reflected in the process of making and sharing analogies in a classroom setting and therefore support the educational value of self-generated analogies.

1. **Autonomy**: Students oversee their own learning and create their own analogies. In doing so, they can choose what subjects they want to use to explain new concepts. Students are responsible for finding their own analogy, rather than relying on a teacher who provides them with an analogy that might not align with their understanding of things.
2. **Competence**: Students rely on their own prior knowledge to create analogies. By exploring their own knowledge base, students have to find similarities between the new concept and concepts that they already know. Being able to formulate an analogy that relates to their own expertise allows students to reach a feeling of competence.
3. **Relatedness**: Students can relate complex concepts to ideas that they are familiar with and that they are experts in. This can also relate to personal information or personal experiences. In addition to that, students can share their personal analogies with their peers and discuss them and thereby not only learn more about the subject but also connect to their peers. These types of interactions are crucial for a feeling of relatedness (van Roy, 2017.)

2.4. Limitations of learning via analogies

Learning via analogies is particularly effective for more advanced learners with more prior knowledge and who benefit from autonomous learning, as was proven in a study which evaluated the use of self-generated analogies for learning thermodynamics (Haglund & Jeppsson, 2012). However, many learners require support from teachers to recognise relevant relational structures for mapping out analogies (Richland & Simms, 2015). When creating their own analogies, learners risk generating idiosyncratic explanations that make it challenging to verify whether the learner's understanding is in line with scientifically accepted ways of understanding these concepts (Haglund & Jeppsson, 2012; Haglund, 2013). This can lead to an incomplete or wrong understanding of these concepts.

Analogies also have a limited impact when learners receive ready-made analogies, because they then take on a passive role and thereby only remember surface similarities, as opposed to structural information (Blanchette & Dunbar, 2000). Due to this memory problem, learners often face challenges when applying information from one field to another (Kurtz et al., 2001).

For learners to feel competent, it is important that their workload is appropriate to their level of expertise, and they receive constructive feedback and appropriate guidance (Brenner, 2022). When generating their own analogies, students could be overwhelmed by the workload, as they are dealing with a stream of new information and the task of finding a concept that it can be mapped to, at the same time. What can be concluded from this is that analogies are not an ideal learning tool for everyone and all situations.

2.5. Tabletop Games/ Serious Games

According to a literature review on 129 empirical papers on the educational value of computer games and serious games, exposure to serious games can lead to improved performances regarding memory and knowledge acquisition and has a positive impact on cognitive skills, such as working memory, addition and auditory perception (Connolly et al., 2012). While some research argues that games can be just as effective, if not more effective, other researchers argue that games can also have a negative impact on learning (Clark et al., 2016). However, research also shows that the design of the game itself is what matters to create an impact on learning (Clark et al., 2016). Therefore, serious games need to be designed in a way that targets certain learning outcomes and behaviours.

Through a tabletop game, players could be encouraged to generate their own analogies in a playful setting which can put players with less prior knowledge more at ease, as they can explore the

processes that are involved in analogy-making without serious repercussions (Angafor et al., 2020). As previously stated, many studies highlight the benefit of learners actively engaging in analogy-making, but those studies do not provide much guidance for how learners can generate their own analogies. A game would give the players an opportunity to engage with analogical reasoning actively and mindfully without the additional stress of processing new learning material at the same time. Serious games focus on the development of knowledge, skills and behaviours through game mechanics that usually involve rules, challenges and interactions (Gobron et al., 2017). Thus, they offer the chance to train these skills, as they are inherently practical and can be designed in a way to encourage a certain set of behaviours (Viudes-Carbonell et al., 2021). Such a game should lead to a better understanding of analogies and remove some of the barriers in learning via analogies.

III. Case studies

Given the challenge of designing a tabletop game that is enjoyable and delivers educational value, various serious games and games were considered to draw inspiration for the research and design process. This section will explain how serious games are effective at achieving learning objectives and how these case studies relate to *The Analogy Game*.

3.1. Game-Based Chlamydia Awareness Intervention

This research explores how a tabletop game can be designed to educate students about chlamydia and change risky behaviour patterns of teenagers (Jiang et al., 2017). Based on an iterative design process, this study optimises both the design and learning goals of the game. In each iteration of the game, slightly different variations are tested to validate successful mechanics of the game and redesign or discard unsuccessful ones. This is relevant for *The Analogy Game*, as it also aims to balance engagement with the games with its learning objectives.

The game aims to change the behaviour of students by exposing them to situations where they encounter STD's. As students become more familiar with the topic, they learn how to react appropriately. Such a change in understanding and behaviour is also the goal of *The Analogy Game*. By asking players to come up with various analogies, their understanding of analogies improves, and they become better at generating them.

3.2. Tabletop game for Cyber security

In this research, the authors explain that many tabletop games already exist for cyber security incident response teams and that they are effective because the informal format eases participation and facilitates exploration of different procedures (Angafor et al., 2020). Players of the game experience simulations in which they can practise adaptable and collaborative behaviour. Such games focus on training practical skills and knowledge, so that players feel at ease when they really need to apply those skills.

This is also relevant for *The Analogy Game*, as it seeks to create a playful environment where analogy-generation is central, rather than learning a new subject *via* analogies. By improving players' understanding of analogies and giving them an opportunity to practice analogy-generation, players should become more comfortable at expressing themselves via analogies. This in turn can lead to improved outcomes for when teachers and educators decide to use analogies in classroom settings, as students can fully focus on the new learning material. Their analogical reasoning skills can then serve as a tool to learn new topics more effectively.

3.3. Escape Room for knowledge transfer of STEM subjects

Another serious game research that inspired this research is the escape room designed by Thurner-Irmler et al., focusing of knowledge transfer of STEM subjects to the public (Thurner-Irmler et al., 2020). The evaluation of this research was based on answers given by the participants of this research and showed a mix of qualitative and quantitative data. Researchers asked the participants various questions about how they perceived the game and gave an indication of how many positive or negative answers they collected. Thus, this research shows that the impact of serious games does not have to rely on statistical evidence but can also be gathered via questionnaires and self-evaluations from participants. A similar approach was therefore adopted for this research.

3.4. Decision making in games

Nakamura argues that explicitly telling groups to share information or make decisions, leads to much better-informed decisions during serious games (Nakamura, 2020). Unstructured discussions can go on for a long time with no real consensus emerging and can thus be detrimental for learning outcomes. It is therefore important to prepare an environment where discussion and heated debates are possible, and players feel comfortable sharing their opinions with the group. Games should therefore have dedicated moments where discussions happen and have constraints that force the group to reach a consensus. This insight is relevant for *The Analogy Game* as the discussion aspect of the game is a crucial moment where learning occurs. Nakamura's study was therefore helpful for structuring the discussion process (adding a time limit) and adding a moment in which players can vote.

3.5. Dixit

Dixit is a board game where players use their creativity and wit to win. Each player is dealt a deck of cards with illustrations. One player, the storyteller, chooses one of their cards and comes up with a title for it. Other players must then look at their own cards and find a card that matches that description. For Figure 1, the prompt could have been "*Living in a fairy tale*" and resulted in players putting down these cards. The storyteller gains points if not all the players guess their card, while other players gain points if their card is thought to be the storyteller's card. This game requires a lot of creativity and good judgement about other people's way of seeing things. Analogies should also strike a good balance between something that people can easily understand and relate to, but at the same time, be creative enough to catch other people's attention. Dixit players enjoy listening to other people's creative ideas and coming up with their own. These game mechanics are what inspired *The Analogy Game.*

Figure 1

Some cards from the game DIXIT

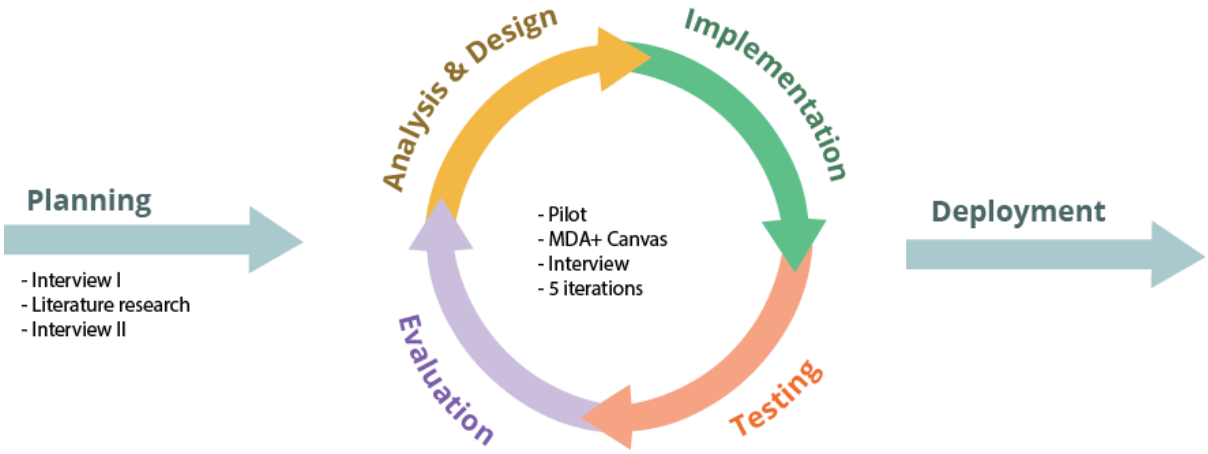
4.1. Iterative design process

This research is based on an iterative design process which creates quick prototypes, and then tests these with participants to gain insights into what improvements can be made to reach learning objectives. This method is suitable for serious games design, as it allows to validate both from an educational and ludic-playable perspective. Each iteration allows to either validate design elements or discard them, thereby creating a solid design basis (Viudes-Carbonell et al., 2021). While the steps within this process can vary, this research followed this structure:

1. **Planning**: At this stage of the design process, literature research around the use of analogies was done to understand how analogies are currently being used in educational settings. Interviews were conducted to learn more about people's general attitudes towards analogies and in order to understand the process behind making analogies. In this phase the learning goal for this game was crystalised, namely improving players' ability to make analogies and there understanding of them.
2. **Analysis & Design**: In this stage, the information that was collected is analysed to lead to different ideas and designs. Different game mechanics are identified which could lead to the desired learning behaviour and aesthetics of the game.
3. **Implementation**: In this phase the design is implemented into a useable prototype.
4. **Test**: The prototypes are tested with groups of people and data is collected via forms.
5. **Evaluate**: Following the advice of Viudes Carbonell, iterative design should validate, change or discard different game mechanics. This was done, based on the observations from the playtests and the responses submitted by the participants.
6. **Deployment**: After the final testing, the game is ready to be delivered.

Figure 2

Different steps of the iterative design process used for this research



4.2. MDA+ Canvas

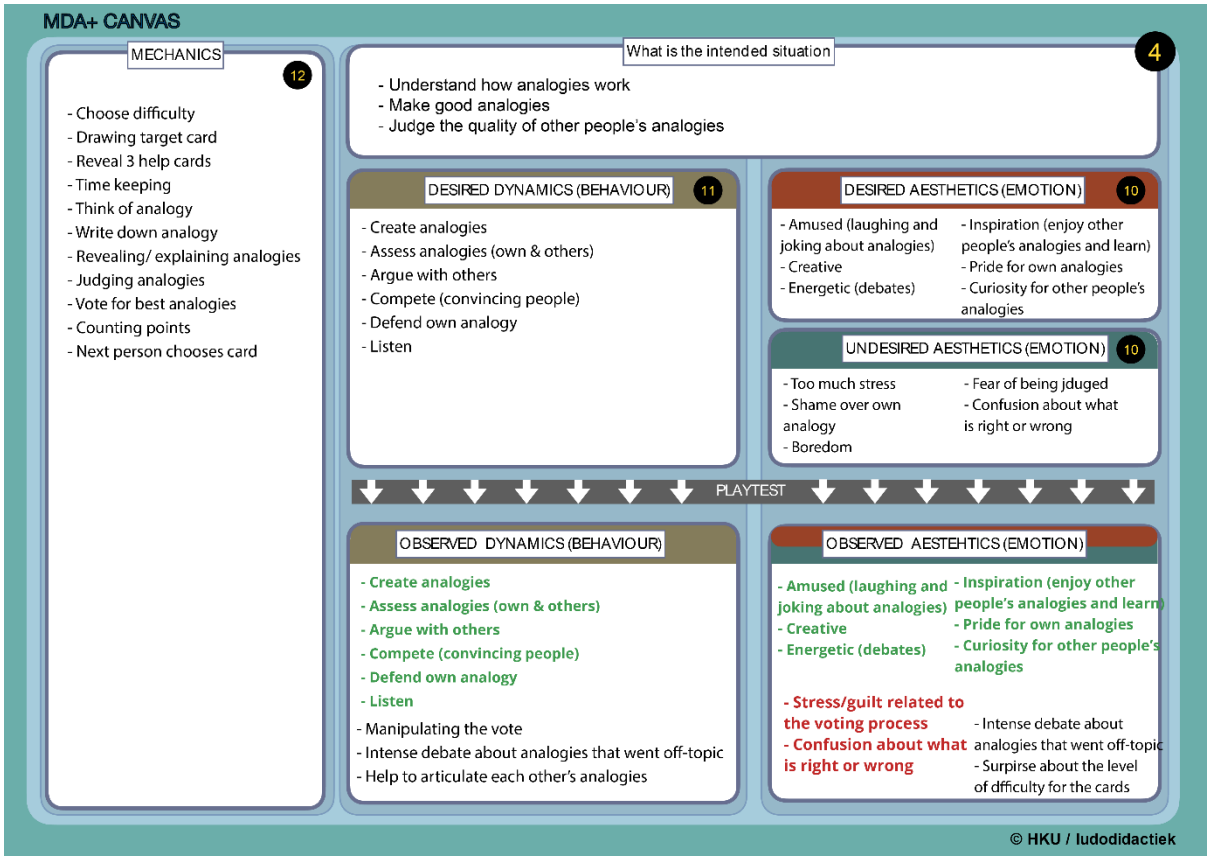
MDA+ Canvas is based on the MDA framework which is commonly used in game design (Hunicke et al., 2004). The original MDA framework can be broken down into 3 components:

1. Mechanics: elements that make up a game and create the affordances for the player. Mechanics are adjusted to evoke desired dynamics and aesthetics. Mechanics can also be validated during playtests.
2. Dynamics: behaviour that is created via the mechanics.
3. Aesthetics: emotional response of players when playing the game and to what extend they enjoy playing the game

The MDA+ canvas adds several elements to this framework to optimise it for learning purposes (Hoogendoorn, 2021). To facilitate the use of this framework for non-designers, the framework is visualised on a canvas. The learning goal is added to the top of the canvas, as it should be central to the design process. In addition to that, there is a differentiation between intended and observed dynamics and aesthetics, as can be seen in Figure 3. This process highlights what elements of the game are successful and which ones need improvement. By isolating certain behaviour and emotions, this process can trace them back to specific game mechanics and inform about changes that need to be made.

Figure 3

MDA+ Canvas



V. Implementation

The following section discusses the development for the game and presents the final design.

5.1. Interview I: Asking About Analogies

Interviews were conducted to get an insight into how people understand analogies, whether they use them and how they used them. In total, 8 people were interviewed.

Table 1:

Interview questions and the most common answers

Interview questions	**Common answers**	**N answers**
Do you know what an analogy is?	Kind of a metaphor	3/8
	Explaining one idea with another idea that has similarities	7/8
	Use a scenario or an example to explain something else	2/8
Is there an analogy that helped you understand something?	Historical analogies	3/8
	Yes, but cannot think of any	5/8
How would you try to make an analogy to explain something to someone else?	It is not a conscious choice; it pops into my head in conversations	3/8
	Try to explain it with something that I know the other person knows or we have in common, use a topic that connects us	5/8
	Think about main process and find similarities in everyday processes	3/5
	Simplify as much as possible	2/8
How do you know if it is successful?	Person's reaction	7/8

Since most people were not able to explain how they generate analogies, it suggests that most people do not generate them intentionally. In addition to that, analogies exist in a social context, meaning that people usually make analogies to explain concepts to other people and the success of these analogies is dependent on that person's understanding of the analogy.

5.2. Interview II: Making an Analogy for Cancer

For the next round of interviews, participants were given a small text about cancer and apoptosis, and asked to come up with an analogy in a thinking-out-loud manner. Afterwards, questions about the analogy-making process were asked. The aim of this interview was to understand how people make analogies, and identify what aspects they found difficult, and which ones they found easy or enjoyable. In total, 6 people were interviewed.

Figure 4

Answers to the question "What was difficult about making analogies?"

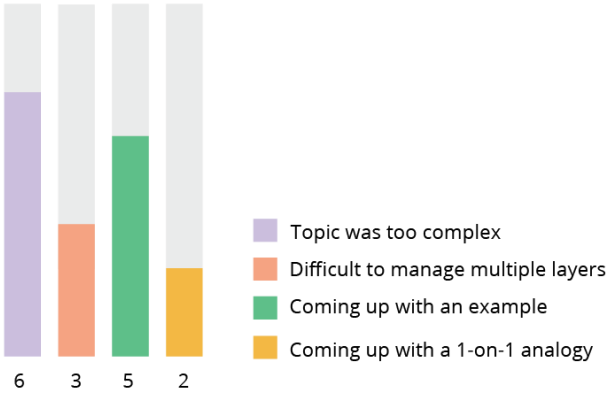
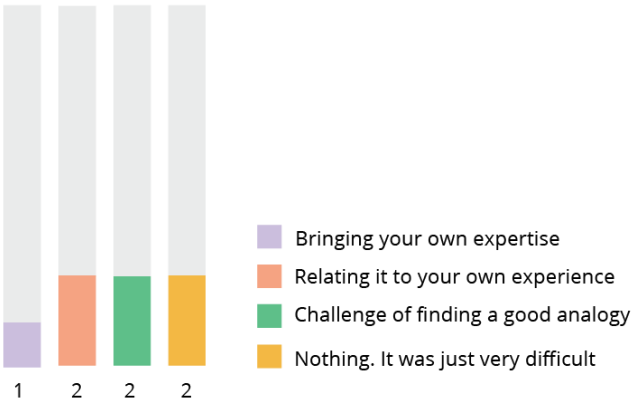


Figure 5

Most common answers to the question "What was easy or enjoyable about making analogies?"



In general, people found it difficult to make analogies to complex concepts and therefore the game should focus on simple ones. While people were quick to understand the underlying process behind the concept, they struggled to come up with an example to form an analogy. This indicates that the game should assist the players mostly in the creative aspects of finding an example that matches the target analogy. While there was no one idea that emerged enjoyable or easy it can be said that people like to make analogies that relate to their own expertise or experience. Thus, the game should focus on making analogies relatable which is in line with previous literature research.

5.3. Final Version

The final version of the game was based on 3 main game mechanics (1) coming up with an analogy and (2) debating which analogies are the most accurate and the most creative, and (3) voting for the best analogies which were validated in all previous iterations of the game. It consisted of instructions on how to play the game and a checklist about how to create good analogies, a playing board, a timer, and different sets of cards. The goal of the game is to make the most creative and most accurate analogies and thereby collect voting cards from other players.

Figure 6

Board during the final playtest

Example cards: At the beginning of each round, three example cards were revealed. These contained some ideas and examples to processes and experiences that the players could make an analogy with. Their purpose was to inspire players and prime their imagination for similar processes. Their design was based on experiential learning which focuses on embodied and physical experiences leading to improved understanding of analogies (Niebert, 2012). In addition to that, interviews with players revealed that the example cards with the most concrete and embodied experiences were considered to be the most helpful or inspiring.

Target cards: The target cards contained the concepts and ideas that players needed to make analogies with. Each target card presented the idea with a short definition.

Practice cards: These cards contained ready-made analogies about natural selection and were distributed among the players in the practice round. Players were each asked to defend them as if they were their own. This round allowed the players to discuss and share their observations about analogies and thereby gain learning experiences before the actual game started.

Voting cards: These cards allowed players to share their votes for the most accurate and most creative analogies with other players. The choice to implement the vote via cards was based on observations during the playtests, showing that players felt more comfortable sharing their vote non-verbally. It also allowed them to distribute their vote and reward more than one player.

Figure 7

Participants while thinking about an analogy

VI. Evaluation

The following section will judge to what extend *The Analogy Game* was effective in achieving the design goal and answering the research questions.

6.1. Participants:

Five iterations of this game were tested with each playtest including 3-5 people with a total of 24 participants. The participants were aged between 20 to 35. All participants were either still in higher

education or had already concluded higher education. Most people who participated in this study can therefore be argued to have a strong interest in learning in general. Participants in each group partially knew each other, there was no group with people who were complete strangers to each other.

6.2. Observations

Generally, participants enjoyed playing the game and made positive comments about the creative aspect of the game, as well as about enjoying the discussion round. All players were able to generate analogies within the given timeframe and in total, there were only 2 cases of someone not being able to generate an analogy.

Players were engaged in lively discussions and pointed out positive, as well as negative aspects of other people's analogies. However, during some sessions, players hesitated when criticising other people's analogies. They tried to avoid confrontation and focused more on positive feedback. In one instance, the researcher encouraged a player to convince others of their analogy, and this led to more lively discussions.

In some iterations, participants did not wait for other players to vote. After the debate, players were very eager to share their vote. This indicates that they felt comfortable sharing their opinions. However, this also conflicts a bit with the previous observation about voicing criticism towards other people's analogies.

6.3. Results

The questionnaires were based on self-evaluations. Results show that most players perceived an increased understanding of analogies and had the impression that their analogies became better throughout the game. This concludes that the game has a general positive impact on players.

Figure 8

Answers to the question "Do you have a better understanding of what an analogy is now?"

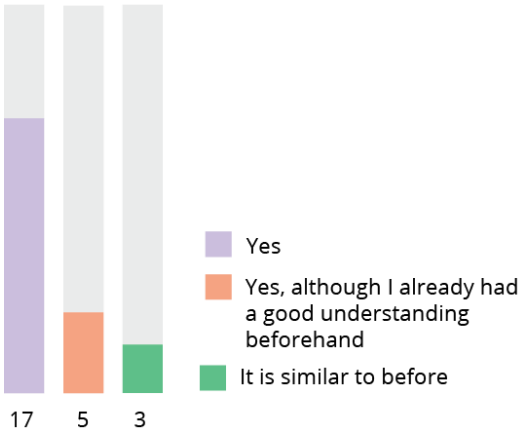
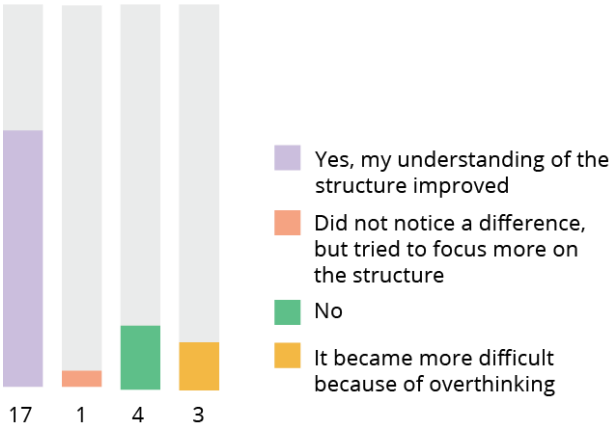


Figure 9

Answers to the question "Do you think your analogies became better as the game progressed?"

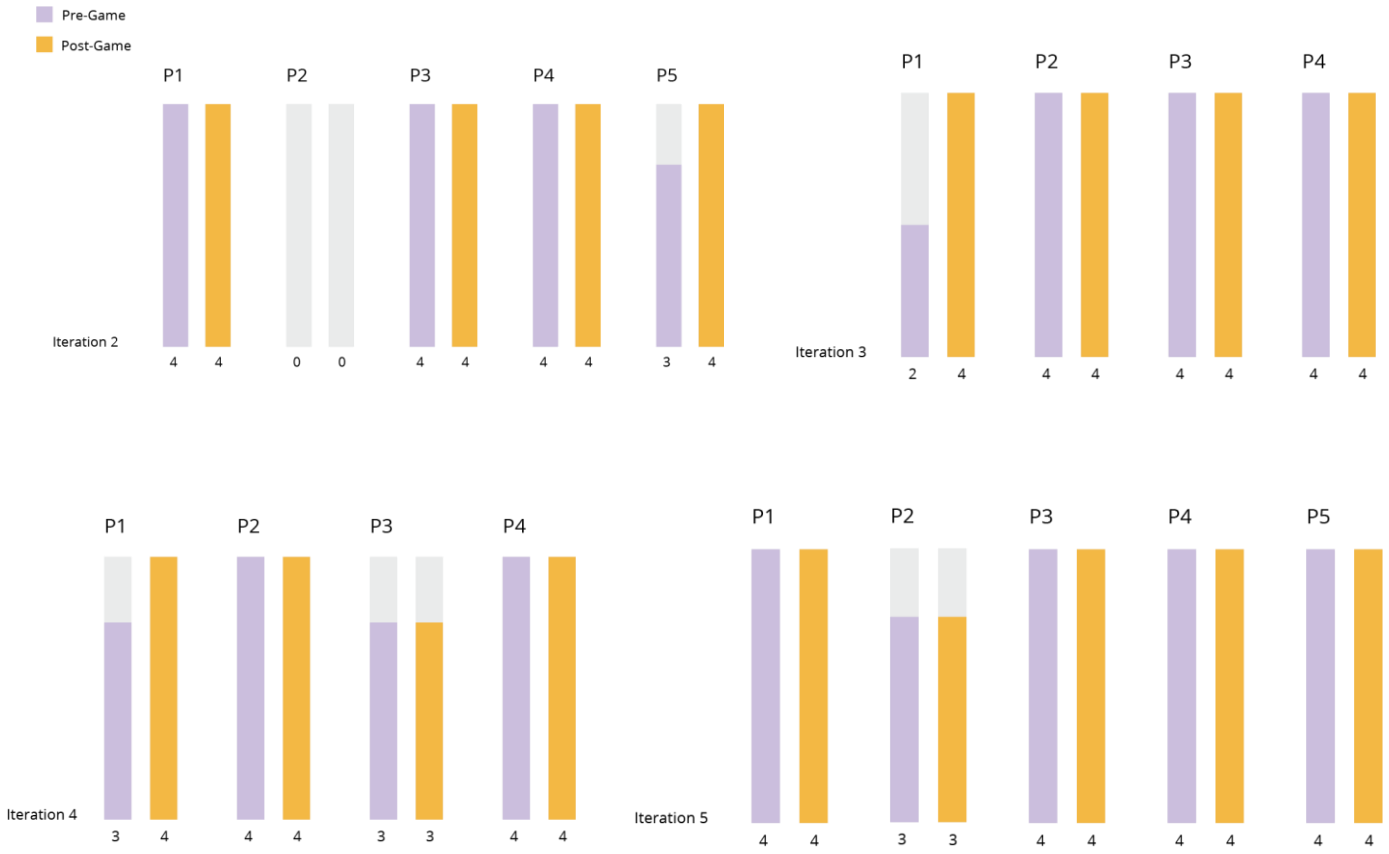


To evaluate the analogies from a more objective perspective, the Divers' Four Core Questions for Arguments from Analogy framework was used (Meinertsen, 2015). According to this framework, only three players' analogies improved, meaning that there is not really a trend towards improved analogies after the game. However, this framework focuses on the argumentation value of an analogy, as opposed to how creative, elaborate, or precise an analogy is. Analogies that are structurally valid would thereby always score 4 points, even if one of the analogies were to map out

more similarities than the other. What needs to be considered is that participants might have experienced less stress when filling in the form, since there was no time pressure.

Figure 10

Results from the analysis of analogies before and after the game



VII. Conclusion

7.1. Design goal:

The design goal of this research was to investigate how a game could be designed to help people learn more about how analogies are made and to help them improve their own analogy-making skills. *The Analogy Game* with a focus on the three main game mechanics (generating analogies, discussing them, and voting on them) offers one possible solution to achieve. The general aesthetic response towards the game was very positive and people were very enthusiastic after playing it. Most of the desired behaviour and aesthetics from the MDA+ Canvas were also observed during the playtests. It can therefore be concluded that tabletop games can serve as a tool to increase people's understanding of analogies and improve their analogy-making skills.

7.2. Research question

Data that was collected demonstrate that players experience a perceived improvement with regards to their understanding of analogies, mostly in terms of how analogies work and how to structure a good analogy. In addition to that, most players were also under the impression that their analogies improved as the game progressed. Players expressed more confidence as the game progressed.

This learning outcome was supported by the main game mechanics that involved creating analogies, engaging in debates about them and voting for the most accurate and creative analogies. Players need to engage with the target cards on a structural level to create a well-mapped analogy. In addition to that, the game rewards people for making creative analogies, thereby encouraging the creation of novel analogies. The discussion allows participants to learn from each other, make arguments for their own analogy and against those of others.

The evaluation of the analogies made before and after the game did not reveal any notable improvements. This could be explained by looking at the framework that was used for this analysis. Divers' Four Core Questions might not have been suitable for measuring how good an analogy is, in light of this game's main goal, which was to generate creative, accurate and elaborate analogies.

7.3. Who is this game for?

The Analogy Game is based on learning theories that rely on the self-sufficiency of the learners. Both constructivism and SDT emphasise the importance of autonomy and the learners' willingness to take responsibility over their learning. Both learning theories also rely on support from teachers and experts to guide the learning process and provide feedback. However, the final version of this game was not designed with a game facilitator in mind and is therefore only suitable for players with high level of curiosity and well-developed skills in abstract thinking and knowledge transfer. Players need to be competent enough to listen to other people's arguments, debate with their peers and process feedback in a constructive manner.

The current version of the game might still be successful in high schools where students already possess advanced abstract thinking skills. With teachers as facilitators, the game could be used to improve students' abilities in language, debate, and logical reasoning. As this game included four rounds and is ideally played in groups of 3-5, one teacher could be present during one round for each group for classroom with up to 20 students.

VIII. Further research

8.1. Game facilitator

In educational settings, learners benefit most from analogies if there is sufficient scaffolding provided by a teacher or an expert (Gray & Holyoak, 2021). A study, focusing on the use of analogies in education, demonstrated that proper scaffolding and guidance from teachers are crucial to benefit learning objectives (Martin et al., 2019). Although this game was designed to be played without a facilitator, the results indicate that players could benefit from an expert who can lead the discussion into the right direction. A facilitator could encourage players to develop their ideas and defend them. While players in some playtests were open to discuss and critique each other's analogies, some players were more hesitant and avoided confrontation. This could also be addressed with a facilitator who encourages more critique and asks the right questions to the group.

8.2. Voting

Additionally, it would be interesting to investigate how and why people vote for certain analogies in order to understand how the voting process could be improved. Participants can have various motivations for voting, such as voting for their friends, voting for something that they find funny, or voting for something because they can relate to it more. Therefore, the voting process was not always indicative of who made the most accurate or creative analogies. In this case, a game

facilitator could also help to make the voting process more objective by summarising valid arguments that were made before the voting starts.

8.3. Evaluating data and framework for analysing analogies

Further research could investigate how a new framework could be made to evaluate the analogies that are made during this game. This framework would consider that the goal of the game is to make the most creative and most accurate analogies and therefore give scores based on factors such as number of features and characteristics that were mapped out, originality, and structural validity. Once such a framework has been created, it would be interesting to also evaluate the analogies that were made during the game and make a comparison to how the players vote. Ideally, players' vote should align with analogies that score high through this new framework.

8.4. Improvements:

Recommendations for future iterations of this game could be an adaptation of this game for different audiences. Game mechanics might have to be simplified or gamified more. Visual maps could be added to support players in making analogies and the debate and voting process could also provide more guidance for the player by providing some questions that players can ask themselves to judge the quality of the analogies. Additionally, further research could be done to optimise the target and example cards. While this research focused on creating the general game mechanics, much research can be done about what topics and examples are ideal for generating the best analogies.

8.5. Long term effects

Further research could also investigate how this game could impact learning in the long term. By introducing analogical thinking and reasoning from an early age, learner might be able to use them more flexibly in their every day lives to explain unfamiliar concepts to themselves and discuss them with peers. This might have positive impacts on reasoning, abstract thinking, knowledge transfer and creative thinking.

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