CogCards: Transforming Memory and Learning with Flashcard Games

Investigating Memory Techniques, Cognitive Biases and Gamification Strategies to Optimise Learning Processes

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Abstract

This research and project paper examines the underutilization of flashcards and the prevalence of procrastination among students, focusing on memory problems and lack of motivation as primary obstacles to effective learning. Flashcards have proven to be a powerful learning tool, significantly enhancing comprehension and encouraging consistent, effective learning due to their accessibility. However, despite their potential, many students do not fully utilise flashcards appropriately, often hindered by cognitive biases like the fluency illusion and struggles with procrastination. To address these challenges, we present CogCards, an interactive website that gamifies the learning process through a diverse library of minigames. This innovative and game-based approach aims to enhance motivation, engagement, and retention, thereby improving academic success among Danish students aged 18 to 30. Moreover, CogCards' minigames are specifically designed to counteract these biases by incorporating educational theories and principles that foster active recall and comprehension. Furthermore, the platform is a full-stack web application developed using Flask with Python, SQLite, Javascript, HTML and CSS, ensuring a seamless user experience with regard to ethical and legislative regulations. Despite limitations such as resource and time constraints, CogCards represents a significant advancement in educational technology.

Keywords: *Flashcards, Memory, Cognitive Biases, Procrastination, Gamification*

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1. Problem identification

Problem analysis (AZB)

Flashcards have proven to be a powerful learning tool, significantly enhancing comprehension of study material and encouraging consistent, effective learning due to their accessibility. However, despite their potential, many students do not fully utilise this opportunity. Most people use flashcards inappropriately, failing to leverage the full potential of this effective study tool. Successful learning is further hindered by the struggle of constant procrastination, which students are exceptionally susceptible to. The problem in question is particularly relevant for students, whose academic success heavily depends on their ability to thoroughly understand and successfully revise the course material.

Not only does this problem impact the day-to-day life of the students within the chosen target group, but it has also proven to be significantly relevant for cognitive science, as it extensively builds upon available research in human behaviour and psychology.

Our proposed solution to the problem (AZB)

We would like to address the problem further and focus not only on the immediate consequences, but also dive deeper and target the underlying causes of inefficient learning. Upon breaking down the initial problem and consulting with the target group, it became evident that two of the most impactful causes are memory problems and procrastination. These issues appear to be significantly influenced by a lack of motivation and engagement. Therefore, our approach concentrates on these aspects in our search for a viable solution.

To resolve this issue, we have developed an interactive website, which gamifies learning through flashcards. What differentiates our platform from other available products is the ability of users to choose from a diverse library of minigames, making studying fun and engaging. This approach not only enhances motivation and engagement with the material but also improves retention and concept comprehension. Additionally, the enjoyable nature of the minigames encourages students to study more frequently (Holmes, 2018).

Problem limitation (AZB)

Due to the limited resources and timeframe for developing a sufficient solution for this problem, it was necessary to limit the scope of the problem. To manage these limitations, we decided to narrow our target audience. Therefore, the focus was within Denmark and specifically the target group of individuals aged 18 to 30. Additionally, we targeted students, since the problems our product addresses is particularly relevant to this group. Furthermore, the problem focus was to mitigate the most common cognitive biases for this target group in particular.

2. Background and motivation

Flashcards

Flashcards - an effective studying strategy (AZB)

There are multiple factors that play a significant role in students' successful exam performance. These factors range from the amount of time dedicated to studying, the environment in which studying takes place, to individual differences such as motivation and prior knowledge. Among these, the choice of study method has been proven to be particularly influential. Research has shown that not all study techniques yield equally effective results (Dunlosky et al., 2013). Therefore, selecting an appropriate study method appears to be an essential part of succeeding in the academic environment, as it can significantly impact a student's ability to comprehend and retain course material.

One of the most commonly used study techniques are flashcards, particularly for subjects that require memorization of key terms and concepts. A recent study conducted on 472 introductory psychology students at UCLA has found that 62 percent of respondents reported using flashcards regularly as part of their studying routine (Hartwig & Dunlosky, 2012). Part of their popularity is likely tied to the fact that students can easily create their own flashcards or use various computer applications to generate flashcards effortlessly. Other than that, flashcards offer several advantages: they promote active recall, facilitate spaced repetition, and can be easily customised to fit individual learning needs. Additionally, the use of flashcards can make studying more engaging, as they often transform the process into an interactive activity. This widespread adoption of flashcards among students underscores their effectiveness and popularity as a study tool.

Flashcards efficacy according to research (AZB)

However, the actual effects of flashcard usage in classrooms are unclear, as research provides mixed findings. For instance, one study examined student performance within a naturalistic context (Golding et al., 2012). It compared exam performance of psychology students who chose to use flashcards as their study method to those who did not during three subsequent exams. It found that students who used flashcards on each exam had higher scores than students who did not use flashcards. Moreover, students who used flashcards across all three exams had significantly higher exam scores overall than those students who only used flashcards on one or two exams. This suggests that repeated retrieval of information through the use of flashcards may be an effective exam-preparation strategy.

In contrast, the previously mentioned 2012 study by Hartwig and Dunlosky showed no significant results when examining direct correlation between using flashcards and achieving higher GPAs. The authors suggest that the reason for that might be in an inappropriate way of how most of the students use flashcards. Students often use them ineffectively, such as

mindlessly reading the flashcards without actively generating responses. Even when used properly, flashcards may be best suited for memorising factual information and not equally effective for studying all types of material.

Another possible reason for the ineffectiveness of flashcards is that the vast majority of students use flashcards primarily as a tool to assess how well they have learned the current material instead of as a means to learn more deeply. Furthermore, there are several cognitive biases that many students underestimate and do not account for when studying with flashcards.

Cognitive biases of learning with flashcards (AZB)

One such bias is the fluency illusion, where students mistake the ease of recalling information from a flashcard for a deep understanding of the material (Northern et al., 2023). This bias occurs when individuals overestimate their comprehension of a concept due to the ease with which they were able to process the information initially. This misjudgment can be attributed to the clarity and straightforwardness with which the information is presented, leading people to believe they grasp the underlying concepts more thoroughly than they actually do.

Flashcards may cause the fluency illusion due to how clearly and concisely the information is presented. This clarity and perceived simplicity of the term tricks the brain into believing that the information is in fact much simpler and therefore easier to grasp. In reality, this feeling is only an illusion of knowledge and their actual understanding is superficial.

Another relevant cognitive bias is the illusion of explanatory depth, which refers to the phenomenon where people believe they understand complex concepts with much greater precision and depth than they actually do (Rozenblit & Keil, 2002). Students often fall into this trap by reading a term on a flashcard and relying on their sense of familiarity with the term, rather than making a genuine effort to articulate or explain the concept. They might assess their knowledge based on how confident they feel about recognizing the term instead of actually testing their understanding by providing a detailed explanation. One reason for this could be that generating explanations requires more cognitive effort and critical thinking, which students might subconsciously avoid, opting instead for the more effortless feeling of familiarity.

Lastly, the hindsight bias, often referred to as the knew-it-all-along phenomenon (Son & Kornell, 2010). Hindsight bias occurs when people, upon learning the outcome of an event or the answer to a question, greatly overestimate their prior knowledge of the event or the answer's obviousness. In the context of studying flashcards, it comes into play when students flip the flashcard too early and reveal the answer before they have attempted to recall the correct definition themselves. After reading the answer they might believe they have known it all along even if in reality that was not the case. This can lead to an inflated sense of understanding and hinder effective learning, as the students do not accurately gauge their actual knowledge and areas needing improvement.

Cognitive limitations in learning

Memory (AZB)

Learning is a process humans have been relying on for thousands of years. It has been defined as a reflective ability, which enables one to draw upon previous experience to understand and evaluate the present, in order to shape future action and formulate new knowledge (Watkins et al., 2002). This definition highlights awareness as an essential part of the process. For learning to be the most effective, the learner must relate new terms to existing meaning in an active manner. This is usually achieved by engaging in various interactive and reflective learning activities. By actively seeking connections between new information and what they already know, individuals can deepen their understanding and retention of new complex concepts.

Memory is a complex mental process that has a fundamental role in human functioning and learning. Without memory, we are capable of nothing but simple reflexes and proceduralised actions. Thus, it is no wonder that memory and learning have been subjects of countless intensive research in the field of neuroscience (Okano et al., 2000). For the purposes of this paper and due to its limited capacity, we will not be delving into the inner workings and processes of memory. Instead, we will focus solely on the effects and mechanisms relevant to the development of our website.

One such effect is the testing effect, also referred to as active recall or practice effect. This effect refers to the common finding that retrieving information from memory can strengthen one's long-term memory of the retrieved information (Rowland, 2014). When students have been tested on material they remember more in the long term than if they had repeatedly studied it, for instance by rereading. There are clear and direct implications of the testing effect for student learning (Karpicke et al., 2009). One way for students to enhance their learning would be to practise recalling information while studying, for example with the use of flashcards.

Another relevant mechanism is called the spacing effect, sometimes also referred to as the benefit of distributed practice. It is a well-known fact that repetition improves retention (Karpicke & Roediger, 2008). However, there is more to enhancing memory and recall than just mindless, massed cramming. A great number of studies in cognitive and educational psychology have demonstrated that spacing out repeated encounters with the material over time produces superior long-term learning, compared with repetitions that are massed together (Cepeda et al., 2006). This principle applies not only to the individual instances, such as spacing individual flashcards in a deck, but also to scheduling entire study sessions (Kornell, 2009).

Procrastination (AZB)

One of the most significant barriers that hinders effective learning is procrastination. It is defined as a voluntary and unnecessary delay of intended tasks that must be completed (Klingsieck, 2013). The person irrationally postpones working on the task, despite being well-aware of the potential negative consequences it might entail. It is frequently accompanied by subjective feelings of discomfort. In the academic context, procrastination refers to postponing academic tasks, such as writing exam papers, completing written assignments, studying, or keeping up with weekly readings, until the last moment, which in many cases is minutes before the assigned deadline. Chances are, we have all experienced procrastination and its negative effects in our lives, as procrastination is a common problem in today's world.

Research shows that the occurrence of procrastination in everyday life is indeed widespread, with studies reporting prevalence as high as 20-25% in the general population. This issue is even more pronounced in academic settings. Alarmingly, estimates indicate that approximately 80% to 95% of students engage in procrastination (Steel, 2007), up to 70% of university students identify as procrastinators (Schouwenburg, 2004), and 50% report procrastinating consistently and problematically (Day et al., 2000).

Among a few, the negative effects of procrastination involve elevated stress levels, decreased satisfaction and lower self-confidence, often due to feelings of self-criticism and disappointment directed at oneself. Failure to complete certain goals or tasks on time can be especially impactful if it involves letting other people down or falling short of expectations set by authoritative figures, colleagues, friends or family. This can not only damage personal relationships but can also tarnish one's professional reputation, leading to missed opportunities and a cycle of negative consequences that reinforce the habit of procrastination.

The underlying causes for procrastination are not generally agreed upon, as there are multiple theories on the psychological origins of procrastination. One of such theories that seems to be the most supported, the temporal motivation theory (Steel & König, 2006), highlights motivational problems as the main cause of procrastination. Similarly, empirical research focusing on academic procrastination supports the notion that procrastination is a motivational problem that involves more than poor time management skills or trait laziness (Senécal et al., 1995).

Another such theory, drawing on the phenomenon of hyperbolic discounting, underscores failure in the self-regulatory and emotional systems as the key cause of procrastination (Zhang et al., 2019). It explains procrastination as an effect of prioritising immediate mood improvement over achieving long-term objectives. It is closely tied to the phenomenon of instant gratification, which has become increasingly widespread, due to prevalent social media addiction and predominance of short-form content.

Research in the product development

The impact of gamification and game-based learning (AZB)

Gamification is the process of applying game features - such as points, badges, leaderboards - to a non-game context. For instance, in the academic environment, students might be awarded for completing certain tasks or there might be a leaderboard comparing each person's scores (Hamari et al., 2014).

The purpose of introducing gamification is to enhance student motivation by making the experience of learning more enjoyable and engaging. By invoking gameful experiences, the process of learning becomes more appealing, and students feel more encouraged to participate actively (Caponetto et al., 2014). Numerous empirical studies have demonstrated the positive impact of gamification on motivation and engagement (Hamari et al., 2014).

Gamification often complements game-based learning, which is learning by playing games. This approach not only develops students' strategic thinking and problem-solving skills, but also improves information processing abilities. Moreover, it enhances social skills by encouraging cooperation and collaboration with other members. Compared to traditional learning, this approach captivates students and intrinsically motivates them to engage and learn, making the process more effective and enjoyable (Monish et al., 2022).

A limited number of studies have found a link between gamification and decreased procrastination, which suggests that more research needs to be conducted. However, those that have examined the connection concluded that gamification has a positive effect on limiting students' procrastination behaviour, due to increased motivation (Tatli et al., 2023).

UI and UX psychology (CH)

First and foremost, CogCards applies the theory of the Zone of Proximal Development (ZPD), developed by the Russian psychologist Lev Vygotsky (Vygotsky, 1978). According to this theory, a student can gradually improve by personalizing learning to consistently align with their ZPD. This ensures the content remains appropriately challenging.

Additionally, CogCards utilises a pedagogical approach known as scaffolding, which builds on the zone of proximal development (Wood, Bruner and Ross, 1976). In scaffolding, the goal is to support students in building their knowledge and skills by giving them progressively more challenging tasks while providing the necessary support and guidance (Wood et al., 1976, p. 90). This approach is integrated into the platform's design, allowing students to gradually enhance their understanding of key concepts and terms through interactive flashcards, memory techniques, and mini-games. By working within their zone of proximal development, students can effectively avoid learning plateaus and steadily improve their academic performance.

Furthermore, Categorization of didactic digital learning resources is a way to classify and identify different types of learning resources (Gissel & Skovmand, 2023). Firstly, training resources focus on training and practising specific skills or tasks. Secondly, informative resources focus on presenting and conveying information and knowledge about a specific topic. Thirdly, scaffolding resources focus on supporting and guiding the student in learning and performing tasks. Finally, profession-simulating resources focus on simulating and mimicking specific situations or tasks that the student may experience in the real world. This categorization has been employed to devise an appropriate approach for gamifying learning.

Originating from Gestalt psychology (Wertheimer, 1912), the Gestalt laws are a set of principles that describe how the brain perceives and groups shapes, colours, and figures to form a holistic picture (Wagemans et al., 2012). These laws can be instrumental in creating a graphic design that is more manageable and user-friendly.

Hick's Law, also known as the Hick-Hyman Law, is a psychological principle that describes the relationship between the number of choices presented and the time it takes for a person to make a decision (Hick, 1952) and (Hyman, 1953). It was named after British and American psychologists William Edmund Hick and Ray Hyman. The law states that the more choices you present your users with, the longer it will take them to reach a decision. This is because when we are met with too many options, our internal information processes become overloaded, which may lead to decision fatigue, delays in decision-making, information overload, and indecisiveness.

Lastly, the "Three-click rule" can serve as a solution to Hick's law and suggests that users should be able to reach any function or content on a website within three clicks or interactions (Dilen, 2022). The idea is to keep navigation simple and efficient, enhancing the user experience.

3. Market conditions

Products available on the market (AZB)

With flashcards being one of the most commonly used study methods, the market is naturally full of learning tools and platforms utilising a digital version of proven standard flashcards, such as Brainscape or Quizlet. The available research is mostly consistent, concluding that digital flashcards outperform traditional paper flashcards in vocabulary learning (Ashcroft et al., 2018; Xodabande et al., 2022). However, little empirical data is available in terms of comparing the effectiveness of digital versus traditional flashcards for purposes other than learning vocabulary.

Therefore, it appears that although it provides students with many more possibilities of customisation and facilitates the process of creating and studying the material, merely digitalising flashcards is insufficient for maximising their educational impact. More needs to be done to fully harness the potential of flashcards in effective learning.

Target group analysis (AZB)

We conducted a survey on a sample of 40 representatives from our target audience to further validate the relevance of our problem observation. The results confirmed that procrastination is a common issue. An overwhelming number of 35% of respondents declared that they ‘always’ procrastinate. Additionally, 85% of respondents reported struggling with remembering terms or details when studying. The survey also highlighted that people enjoy playing games; when asked to rate how much they enjoy games by choosing a number on a scale from 1 (not at all) to 5 (very much), the majority selected 5, resulting in an average of 4.45.

After developing our product we conducted beta testing to further evaluate the relevance of our product and ensure the development process was headed in the right direction. We collected valuable insights, which enabled us to further adjust the product to better cater to our users’ needs.

The beta test included participants aged 15 to 53, mainly male (60%) and all from Denmark. Although 80% rarely used flashcards, 60% enjoyed the games, rating them 4 out of 5. The design and navigation were positively received, with 80% finding the navigation intuitive and 60% liking the design. Feedback on using the site for studying was mixed. Users suggested a sticky menu, more hyperlinks, a darker theme, vibrant colours, a chatbot, and AI-generated questions. While unique, the product had some similarities to other tools. Participants enjoyed the music and wanted more content and interactive features.

Persona (AZB)

A persona is a semi-fictional profile of a typical member of a target audience, based on real data and research, including demographics, behaviour patterns, goals, and challenges. (Hakobjanyan, 2024). Based on the survey's results we created a fictional persona, which is a personification of our target group. The characteristics of the persona - its goals, needs, expectations and behaviours - strictly correspond to the profile of the target group.



Sofie Jensen

2nd Semester Student

Age: 23 years	Currently residing in: Aarhus, Denmark
Sex: Female	Education: Aarhus University
Birthplace: Copenhagen, Denmark	Degree: Nordic Literature Student

BIOGRAPHY

Sofie has started university after having two gap years, which she spent travelling and getting to know herself better. After such a long break she struggles with adjusting and getting into the flow of studying again.

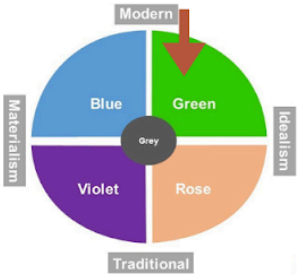
STUDYING HABITS

Sofie struggles with procrastination. She prefers playing games to studying. She tends to postpone her studying sessions until just a couple of days before her exams. She struggles with remembering terms.

GOALS AND OBJECTIVES

- Stop procrastination
- Study regularly
- Improve retention
- Score high on exams
- Make studying more enjoyable
- Improve personal gameplay

MINERVA MODEL SEGMENTATION



QUOTE

"I find myself not engaged in studying at all. No matter how hard I try, I can't get into it. It doesn't help that I can't remember the terms I study. It's demotivating."

SKILLS

Scheduling ★★☆☆☆

Memory ★★★☆☆

Using digital tools ★★★★☆

Competitor analysis of Brainscape (CH)

First of all, one of Brainscape's notable strengths lies in its numerous subjects that are freely available, which fits a wide range of university students within the company’s intended demographic (Ramsay, 2024). Moreover, Brainscape's utilisation of flashcards to enhance memory and learning underscores a significant strength of their product, rendering it highly valuable. Furthermore, this personalised approach is also in line with the "Zone of nearest proximity" theory for personal growth, as it allows students to focus on the flashcards they find most challenging. However, it is important to note that this approach may not be suitable for all students, as some may prefer a more meticulous approach to learning (Saatz, 2013).

On the other hand, the lack of diverse learning methods beyond simple flashcard viewing and self-assessment could contribute to user dissatisfaction and limited effectiveness in truly obtaining the desired knowledge retention often attributed to the illusion of explanatory depth (Roeder et al., 2015, 2016) and (Rozenblit, L., & Keil, F.C, 2002). Brainscape's reliance on this single learning approach may inadvertently reinforce this cognitive bias, representing a weakness for the company.

Opportunities for future automatic creation of courses lie in leveraging user-generated content, particularly through the creation of flashcards accessible to all users unless made private by premium subscribers. This approach taps into a perpetual pool of potential contributors, ensuring a steady stream of diverse course material. Moreover, as computer usage continues to rise in today's digital era, such initiatives hold increasing relevance, presenting avenues for expansion and innovation within the educational landscape (Collis, 1996).

In the realm of threats, Brainscape faces competition from various sources, including other established companies such as Quizlet (Noakes, 2023). Additionally, there is a growing trend of products similar to Brainscape that are utilising flashcards in their learning-platforms.

4. High-level description of our solution

Idea description (CH)

CogCards is an innovative app and website designed to boost student learning using interactive flashcards and different minigames with the flashcards. It draws on proven research about the effectiveness of flashcards, offering a unique approach to mastering key concepts and terms (Golding et al., 2012).

By incorporating memory techniques, minigames, and evidence-based learning strategies, CogCards transforms traditional flashcard use into a dynamic and engaging learning experience (Lister, 2015). The platform provides various modes for engaging with educational content, including traditional flashcards that users can flip through, Jeopardy-style quizzes where definitions are displayed and users must type in or define the corresponding terms, and mini-games like “TetriCards”, where correct terms remove blocks.

CogCards leverages effective cognitive science techniques such as the testing effect to avoid cognitive biases in learning. Rooted in extensive research on learning, biases and memory, CogCards emphasises not only memorization but also understanding the material through interactive questions and comparisons.

Product development (CH)

To document the process of developing the product and to work together on the product in real time, GitHub was used in correlation with VSCode.[1] The plugin for GitHub called, GitGraph, was utilised to showcase the development of the product via commits throughout the project.[2]

Medium choice (CH)

Using a website as a platform for developing an application for learning flashcards offers several advantages. Websites provide a versatile platform where users can create, manage, and study digital flashcards (*Scholarly blog*, 2023).

To examine the website and ensure effective interaction between the product and its target group, Laswell’s communication model was employed (Lasswell, 1948). The sender is CogCards and the message is the unique value proposition of CogCards of gamifying learning. This channel, the website, is targeting a receiver, who might be attracted to the gamification aspect of the product (Chambers, 2005). Lastly, the effect, or the intended outcome of the communication, is to motivate the target group to use the product.

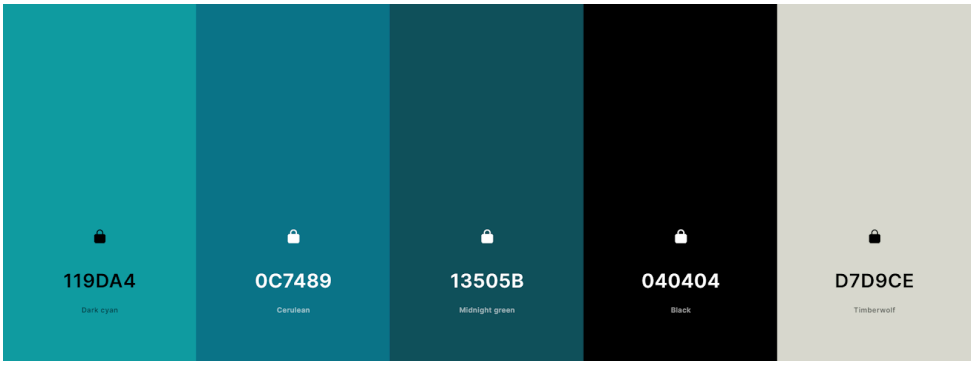
[1] View the appendix to get the link to the GitHub repository
[2] View the appendix for the Git Graph development

Design process (AZB)

Much thought and effort was put into the design, as it constitutes a large part of what makes our product so attractive. We aimed to ensure it was intuitive and easy to navigate, while still maintaining appealing visual aesthetics.

We started by gathering data and drawing on the existing research on UI and UX principles to utilise them in the creation of our website. We used Figma to create a flowchart, which helped us plan the structure of the website and organise its sections. We utilised the ten usability heuristics (Nielsen, 1994). After ensuring the navigation was intuitive, we built upon the flowchart and created a mock-up version of the website using Marvel App. This enabled us to visualise how the end product would look.

After finalising the layout, we focused on the style. First and foremost, we decided to follow a monochromatic colour scheme, as it is the easiest to create and apply. Then we used the website “Coolors” to create a palette, which we limited to include three different hues of blue, accompanied by two neutral colours - black and white. Here, we chose blue as the primary colour, as it is often associated with calmness, professionalism, and focus. These associations fit the general vibe we were aiming for as a learning platform. Lastly, we implemented the 60-30-10 rule, which dictates the proportions of colours in the colour palette, to ensure balance.



Additionally, much thought was put into the choice of font, as readability is key for functionality. Research shows that reading times vary between fonts; however, individual preferences for readability and ease differ among users, making it impossible to find a universally perfect font (Wallace et al., 2022). Furthermore, characteristics of a font significantly influence its perception. Research suggests that angular and spiky shapes are perceived as more aggressive and attention-grabbing, while curvy and circular appear more comforting (Carolis et al., 2018). Therefore, we settled on using Calibri for its slightly rounded design, which offers a soft look while maintaining a formal appearance.

Final solution (CH)

The product's codebase is structured to facilitate a seamless user experience. The “App.py” routes section is pivotal in this regard, defining routes for various pages of the web application. These include the home page, public library, my decks, the science behind, study & play (minigames), about us, contact and profile. This code also incorporates functionalities for displaying flashcards, navigating through them, handling quiz questions and answers, and providing a search functionality to easily reach every function of the website.

Flashcards (CH)

Flashcards are a powerful tool for learning and memorising information (Schmidmaier et al., 2011). In the webpage, users can create their own decks of flashcards on various topics, which aligns with their goal of studying. Users can view all their decks, search for specific decks, and toggle the table of contents for an overview of all decks. They can also pin their most frequently used decks for easy access, and view the recently visited flashcards.

Minigames (CH)

The title of the page is set to "Study & Play", reflecting the theme of combining learning with fun activities. The header displays the title "Minigames" along with a subheading emphasising the concept of playful learning experiences. Below the header, users can find a search form allowing them to search for specific games, and a sorting dropdown menu for selecting different sorting options.

First and foremost, **CardChase** is a fast-paced game that tests memory recall by questions appearing on the screen and moving downwards, while users must type their answers before they reach the bottom. Correct answers earn points and progress the game, but mistakes or delays result in game over. This game aligns with Lev Vygotsky's theory of the Zone of Proximal Development (ZPD) by offering challenges that are difficult, but achievable with the right amount of support. Additionally, the game uses the principle of scaffolding by gradually increasing the complexity of tasks, thereby supporting users in building their skills step-by-step. CardChase helps counteract the fluency illusion by requiring quick, active recall, ensuring that users truly know the material rather than just recognizing it. This approach leverages the testing effect, reinforcing long-term memory retention through repeated retrieval practice.[3]

The second game, **DefineDash**, presents users with a series of terms and prompts them to type out their definitions. This active recall game enhances comprehension and retention by encouraging users to engage deeply with the material. DefineDash leverages the scaffolding approach, starting with simpler definitions and progressing to more complex ones. This gradual increase in difficulty helps users build their knowledge incrementally, which aligns with the ZPD by ensuring that each task remains within the learner’s capacity to perform with

[3] View image 10-12 in the appendix

support. The game also benefits from Gestalt principles, such as proximity and similarity, to ensure that related elements are visually grouped together, enhancing the user experience. Furthermore, DefineDash acts as a solution to avoid the cognitive bias known as the illusion of explanatory depth, because the player has to write down the answer. By doing so, it also utilises the testing effect, requiring users to actively recall and articulate their knowledge, thus reinforcing memory.[4]

The third game, **Flashcards**, allows users to flip through virtual flashcards at their own pace, reviewing both terms and definitions to reinforce learning through repetition. This mode is primarily based on informative resources, providing users with the opportunity to absorb information and understand key concepts thoroughly. The design incorporates the principles of Gestalt psychology, such as closure and good continuation, to create a seamless and intuitive user interface. By allowing users to navigate between cards easily, marking their progress, and focusing on areas that need more practice, Flashcards helps maintain an effective learning flow. This game helps mitigate hindsight bias by encouraging users to recall information before revealing the answer, making it clear whether they genuinely knew the material. Overall, flashcards provide a dynamic, interactive, and efficient way to learn and memorise information (Bryson, 2012).[5]

The fourth game, **TetriCards**, combines the addictive gameplay of Tetris with the study of flashcards. Users must clear lines by matching flashcards with their corresponding definitions, making learning as engaging as playing a game. This unique twist on the classic Tetris game integrates Gestalt principles to create a coherent and enjoyable experience. The game's design utilises the principle of proximity, grouping related terms and definitions close together to enhance learning. Additionally, the scaffolding approach is evident as the game becomes progressively more challenging, encouraging users to apply their knowledge effectively within their ZPD. TetriCards addresses the fluency illusion by requiring active matching, which necessitates a deeper understanding of the material. It also leverages the testing effect, reinforcing memory through the active retrieval of information.[6]

The fifth game, **TermTime**, is a timed challenge where users must match terms with their definitions as quickly as possible. This game improves memory recall and speed while making learning more exciting. The structure of TermTime supports the ZPD by providing time constraints that push users to recall information quickly yet accurately, offering a balanced level of challenge. The game’s design also adheres to Hick’s Law by limiting the number of choices presented at any one time, preventing decision fatigue and ensuring that users remain focused and engaged (Hick, 1952). TermTime helps counteract the illusion of explanatory depth by requiring quick, precise recall under time pressure, ensuring a genuine understanding of the material. It also uses the testing effect by making retrieval practise an integral part of the learning process.[7]

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[4] View image 13-15 in the appendix
[5] View image 16-18 in the appendix
[6] View image 19-21 in the appendix
[7] View image 22-25 in the appendix

The last game, **Quiz Mode**, presents users with multiple-choice questions based on the flashcards they've studied. It's a fun way to test knowledge retention and track progress. By offering a limited number of choices, this mode follows Hick's Law, ensuring that users are not overwhelmed and can make decisions efficiently (Hyman, 1953). The three-click rule is applied to keep navigation simple and efficient, allowing users to access quizzes and other functions quickly. This mode also incorporates elements of scaffolding by offering different difficulty levels, allowing users to progressively challenge themselves and improve their knowledge retention and comprehension. Quiz Mode helps address hindsight bias by presenting questions without immediate answers, making users commit to their response before seeing if they are correct. It leverages the testing effect by incorporating repeated retrieval and spaced practice into the learning process.[8]

By integrating these educational theories and principles into its games, CogCards creates a rich, interactive, and effective learning environment that keeps students engaged and motivated, ultimately enhancing their academic success.

The Science behind (CH)

In this page of the website, the user will get a brief insight into why using minigames to study flashcards and why the users should use the website overall. This can give a logical rationale for the target group to argue for our product improvement on learning, and to sell the product to a potential consumer.

About us (CH)

The "About Us" page of CogCards, a platform designed to enhance student learning through personalised flashcards and memory techniques, is structured to provide comprehensive information about the platform. The page begins with a header section that prominently displays the title "About CogCards" and includes a "Contact" button for users to easily get in touch. Following the header, the content unfolds in several sections.

The initial section, "Welcome to CogCards," serves as an introduction to the platform's purpose and features, with a special emphasis on its use of flashcards and memory techniques to facilitate learning. Subsequent sections delve deeper into the product's offerings, detailing various learning modes such as traditional flashcard viewing, open-answer quizzes, and engaging mini-games. The "Featured Games" section showcases specific games offered by CogCards, complete with descriptions of each game's mechanics and helpful tips for playing. To round off the page, a "What Our Users Say" section presents testimonials from satisfied users, serving as a testament to the platform's effectiveness and its positive impact on users' learning experiences.

[8] View image 26-27 in the appendix

5. Technical description of our solution

IT - tools (CH)

Working with GitHub in VSCode for our group project was incredibly beneficial. It allowed us to track our progress seamlessly and collaborate effectively. Moreover, GitHub's version control features enabled us to manage changes efficiently and backtrack if we encountered any bugs or issues.

To create a mock-up of the CogCards website, we used Marvelapp, a tool for building interactive prototypes. This helped showcase how the CogCards website should be developed, and was then further used as a template for the product development.

Flowcharts were also used to create an overview of the user-interaction with the website. This was also used as a template for the product development, but also to ensure that all the functions could be accessed within maximum three steps in accordance with the “Three-Click Rule” (Dilen, 2022). In addition, the users should also be able to find the website navigation intuitive, which was kept in mind in the development of the flowchart.

Methods and programming (CH)

In order to realise our ideas surrounding CogCards as a website, it was necessary to utilise a full-stack approach. This entails having backend code to support the programming of the minigames and the frontend functionality on the website in the case of navigation and buttons among others. For users to save their data and flashcards, it was evident that we would have to use a database for the different users' data and credentials in their profile from their login.

In the backend part of the code, it first and foremost sets up a locally hosted web application using the Python library Flask. Flask provides a lightweight framework to build web applications, making it an ideal choice for small to medium-sized projects. The setup involves importing necessary modules, creating a Flask application instance, and defining routes to handle various HTTP requests such as GET and POST (Aggarwal, 2014). The app is configured to run on a local server, which facilitates development and testing.

The database setup section defines functions to connect to and close the SQLite database. SQLite is chosen for its simplicity and ease of use, being a serverless, self-contained SQL database engine (Owens, 2003). The connection function establishes a link to the database file, ensuring that any necessary tables and columns are present in the database schema. This is typically achieved through SQL commands executed within the function, which create tables if they do not already exist. For example, if the application requires a user table, the setup will include SQL to create this table with appropriate columns like id, username, and password.

In the very beginning of creating mock-ups of the minigames, they were programmed in Python with the library Tkinter for creating an interactable graphical user interface (GUI). However, as the development progressed, it became evident that this approach was not ideal for integration into a locally hosted website. This limitation hindered the user experience, as it prevented dynamic interaction and responsiveness expected in web applications.

Consequently, a shift was made towards using JavaScript for game development within the website. JavaScript offered several advantages over Python in this context. Firstly, it enabled the creation of a visually appealing GUI directly within the website, enhancing the overall user experience. Additionally, JavaScript's ability to handle real-time user inputs and dynamically respond to them in the text-field provided a more interactive and engaging environment for users (Aziz & Ridley, 2017).

Furthermore, for the website to also look pretty for the target group and to create the webpages themselves, we used HTML and CSS in the frontend part of the programming. While HTML is a Markup language used to structure the website text and functions, CSS can be used to design the website with the desired styling. CSS styles are embedded within <style> tags to control the layout, colours, and appearance of page elements (Lie & Bos, 1997). Here, it became possible to use the Gestalt principles to create the styling and design in accordance with natural human perception of categories (Wagemans, 2012).

Lastly, jinja2 was used to debug the website, if it encountered any errors (Nipkow, 2003). This was very important, because the frontend HTML templates did not themselves necessarily showcase errors apart from syntax errors. Therefore, the jinja2 could be used to assess the entirety of the website based on all the files in the project. This was primarily used to debug and check if the database worked in accordance with the user and creation of new flashcards.

6. Strengths and challenges of our solution

Unique selling proposition (AZB)

A unique selling point or proposition (USP), is the essence of what makes a product or service better than the competitors. In this case USP is achieved by gamifying learning and utilising flashcards in a completely novel way that no other competitor has implemented and succeeded with.

Similar solutions employing flashcards as a learning medium exist - such as Brainscape or Quizlet, but none have employed gamification and game-based learning as a primary feature and foundation for learning. This is where our solution excels, standing out with its uniqueness and proving its superiority.

Product limitations (CH)

The challenges of our solution present themselves as being limitations in regards to the functionality of the creation of the flashcards. As of now the flashcards cannot be dynamically created and added to the database, but they have to be manually programmed locally in the Python script. Therefore, there are only three available flashcards in the user's personal deck.

The minigames are mostly finished, but some of the functions in the settings should be implemented further. Moreover, TetriCards should be finished with adding text to the falling blocks, and allowing the user to remove the corresponding text as intended. Furthermore, the user could experience the minigames as being a bit too stressful rather than motivating, when having a time limit and or receiving the "Game over" sign after the time has run out (McKechnie-Martin et al., 2024). This was stated by our target group in the initial survey and beta-testing.

Lastly, the product should be made public, so it is not limited to locally hosting the website on your own computer and so it is possible to share decks with the public. This would ensure a steady flow of flashcards on the website created by the website's own users.

Ethical considerations (CH)

Ethical considerations are crucial when handling user-data and conducting research involving people. Before development, potential users, and thus the target group, participated in a survey to assess market interest. To protect participants' privacy, responses were automatically anonymized in both the initial target group survey and the subsequent beta-testing survey. Participants also agreed to a consent form that explained how their data would be used and that they could refrain from participating at any time. This informed consent is important in order to comply with ethical measures (Arellano et al., 2023)

In the context of user privacy, the provided Flask application also takes several ethical steps to ensure the security and confidentiality of user data during the registration process. To protect the user's password, personal information and private decks, the application employs the SHA-256 hashing algorithm from Python's `hashlib` library. This process transforms the user's password into a hashed string, which is then stored in the database instead of the plain text password (Python Software Foundation, 2021). This measure significantly enhances the security of the user's sensitive data. When creating the user in the SQLite database, the application uses parameterized queries to prevent SQL injection attacks (Fadlallah, 2022), further fortifying the application against potential security threats.

Legislative considerations (CH)

To ensure the users' privacy and prevent a potential data leak, it is important to follow the EU regulations of cybersecurity (Negrescu, 2021). With increasing cyber threats, the platform would need to adhere to cybersecurity regulations to protect user data.

As an online platform, CogCards would need to ensure compliance with data protection laws such as the General Data Protection Regulation (GDPR) in Europe (OECD, 2023). On the front page, we for example have used a freely accessible stock-image, which ensures that we do not steal anyone's picture without crediting them. This data protection regulation also includes safeguarding user data and respecting users' privacy rights. Since users can create and modify content, there could also be issues related to content ownership and potential copyright infringement.

The platform would need to meet certain educational standards and web accessibility laws, such as the Web Accessibility Directive (European Parliament and Council of the European Union, 2016) to ensure the quality of its content. In this case, the users can create their own flashcards and thereby adhere to their own curriculum, but the public flashcards should be created to fit with the potential target groups needs.

7. Future directions

Mitigating challenges (CH)

First and foremost, the product can be changed to mitigate the current challenges for example by including the option of not having a time-limit or having an endless-mode in the games. The function of not having a time-limit is currently not fully implemented physically to work with the minigames and only a mock-up on the website. The endless-mode is automatically implemented in the game, Cardchase, but not in the rest of the games.

Instead of the "Game Over" sign, the idea is that the minigames would in further development be changed to show the user a highscores-list. This highscore-list would motivate the user rather than being met with defeat of the "Game Over". Then the motivation could be to beat your previous scores, and be able to feel a sense of accomplishment and improvement in your studies. Currently a mock-up of a high score-list is showcased in the settings before playing the minigames, but is not based on real userdata.

Minimum viable product (CH)

A Minimum Viable Product (MVP) is a version of a product with the least amount of features necessary to meet the needs of early users and gather feedback for future development. (Ries, 2011) The minimum viable product in our case requires a website that is locally hosted using Flask. The website should also host at least two minigames in the minimum viable product. The login system is another crucial component of the website. It allows users to register and

log in. Once logged in, users can write flashcard answers and definitions, which are saved to a local database under the user's name. This comprehensive system ensures a personalised and interactive experience for each user.

Further development (AZB)

Due to time constraints and limited resources we were unable to implement all the functions we intended our website to have. Among those is naturally improved visuals and aesthetics based on Gestalt principles for better user experience. Furthermore, we aim to broaden the gamification aspect by creating a set of achievements one could unlock for reaching certain milestones, such as maintaining streak or setting a highscore.

Next, a tracking function to accurately monitor one’s progress over time and view detailed statistical information about learning sessions. Moreover, we plan to implement spaced repetition and Leitner’s system in a functional way, which as of now exceeds our abilities. Finally, we intend to broaden the game library with a variety of engaging minigames.

8. Conclusion (AZB)

In conclusion, CogCards emerges as a promising solution to address the underutilization and misuse of flashcards, along with tackling procrastination among Danish students aged 18 to 30. By gamifying learning and incorporating principles from cognitive science and gestalt psychology, CogCards enhances motivation, engagement, and learning efficiency while mitigating cognitive biases such as the fluency illusion, the illusion of explanatory depth, and hindsight bias. While facing challenges such as manual flashcard creation and stress-inducing gaming experiences, the roadmap for future development includes user-friendly features and adherence to ethical and legislative standards.

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Appendix

Target group survey results

Link to the survey results:

- https://docs.google.com/forms/d/1yz5QBPT9FAMWf9WU4G3JY-oOHTQ84radm0APmADjMD4/viewanalytics

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Link to the GitHub-repository with the product

- https://github.com/Azrae101/AppliedCogSci.git

Video showcase of the product

Briefly showcasing most of the functions on the website in 5 minutes:

- https://youtu.be/00pThcAwQHw

Pictures of the product

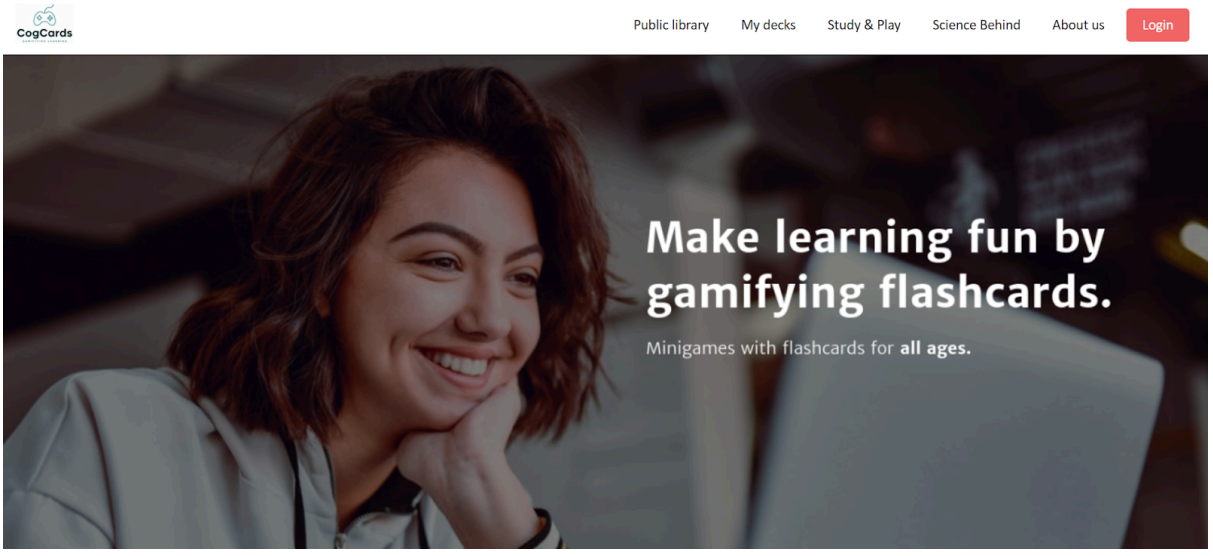


Image 1: The homepage of the “CogCards” website, an educational platform promoting the use of gamified flashcards for enhanced learning experiences.

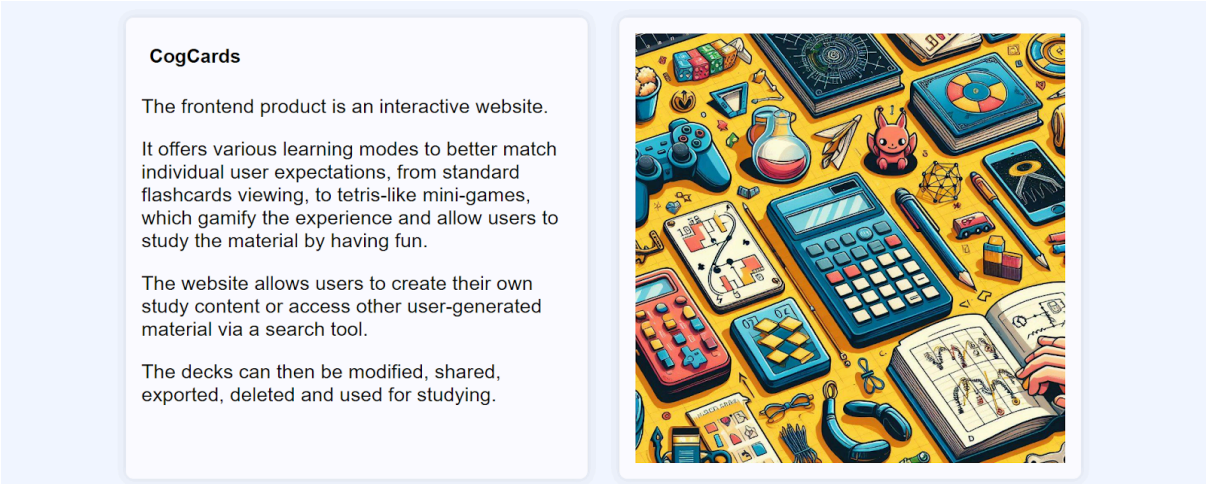


Image 2: The image from the homepage of a website depicts a vibrant arrangement of study tools and gadgets. These include a calculator, notebooks, pencils, a clock, and other learning aids. It creatively encapsulates the essence of studying and learning, likely representing the features of the “CogCards” product mentioned in the accompanying text.

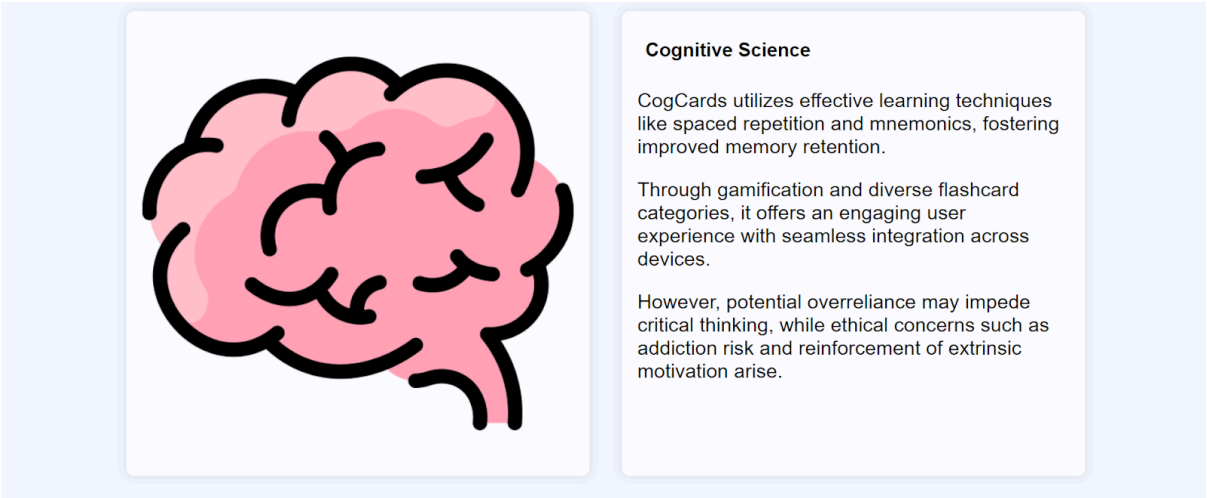


Image 3: The image on the website’s homepage features a stylized pink brain against a light background. The brain symbolises cognitive science and mental processes. Adjacent to the brain illustration, there’s a text excerpt describing ‘CogCards.’ These cards utilise effective learning techniques like spaced repetition and mnemonics to enhance memory retention. The concept also incorporates gamification and seamless integration across devices, emphasising an innovative approach to cognitive development. Overall, it’s an engaging representation of educational tools in the realm of cognitive science.

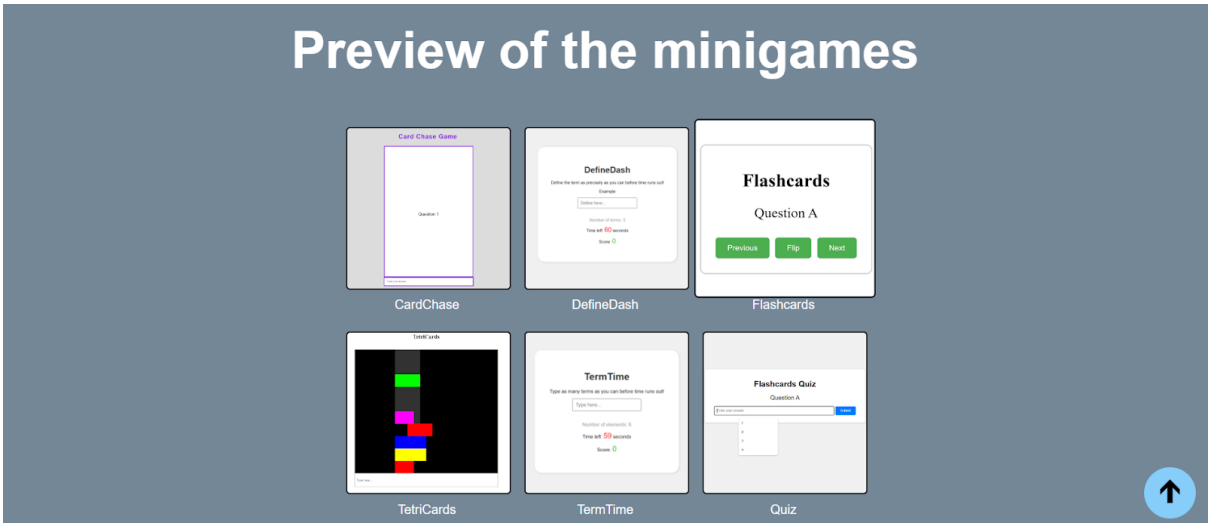


Image 4: The image on the website's homepage displays a preview of various educational minigames. These games include "Card Chase Game," "DefineDash," "Flashcards," "CardChase," "TermTime," and "Quiz." Each game is represented by a simplified graphic of its interface, suggesting a range of interactive learning experiences. The layout is clean and organised in accordance with the gestalt principles of organisation, with clear labels for easy navigation.

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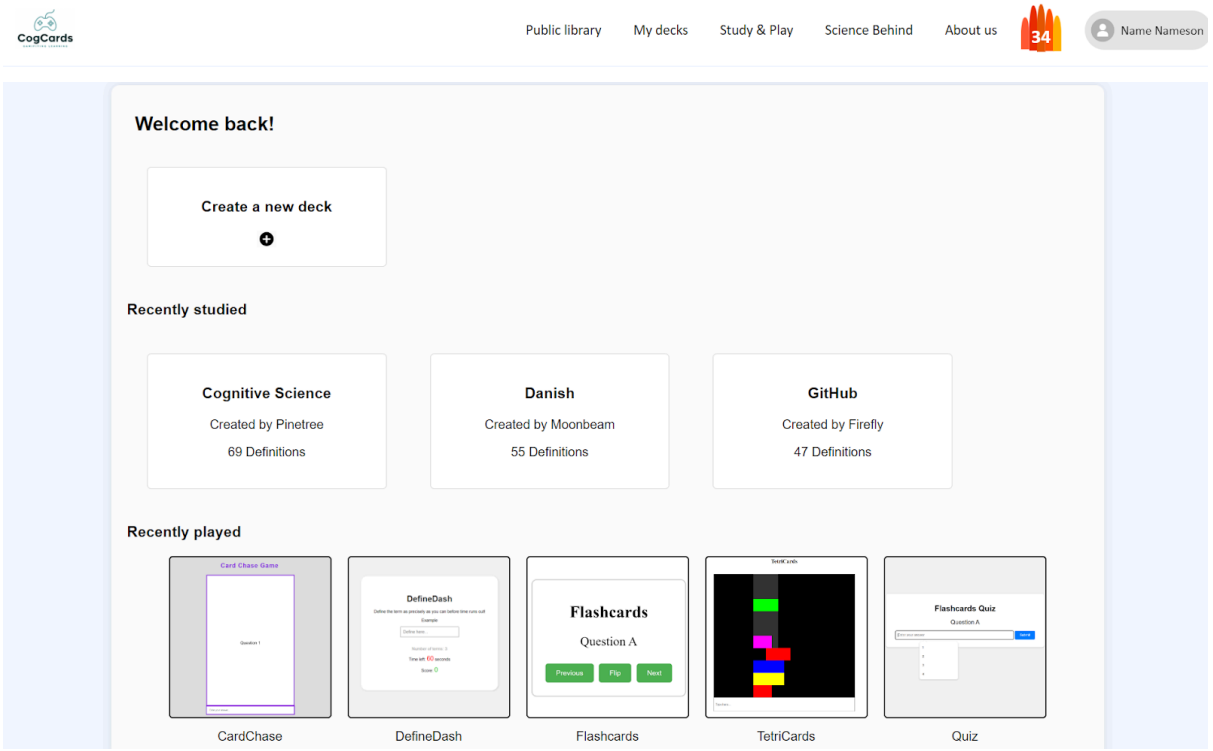


Image 5: The logged-in homepage displays a welcoming message, "Welcome back!" Users can create new decks. Recent study materials include "Cognitive Science" (69 definitions), "Danish" (55 definitions), and "GitHub" (47 definitions). The "Recently played" section features interactive activities like CardChase, DefineDash, Flashcards, TetriCards, and Quiz. It's an engaging interface for learning and reinforcement.

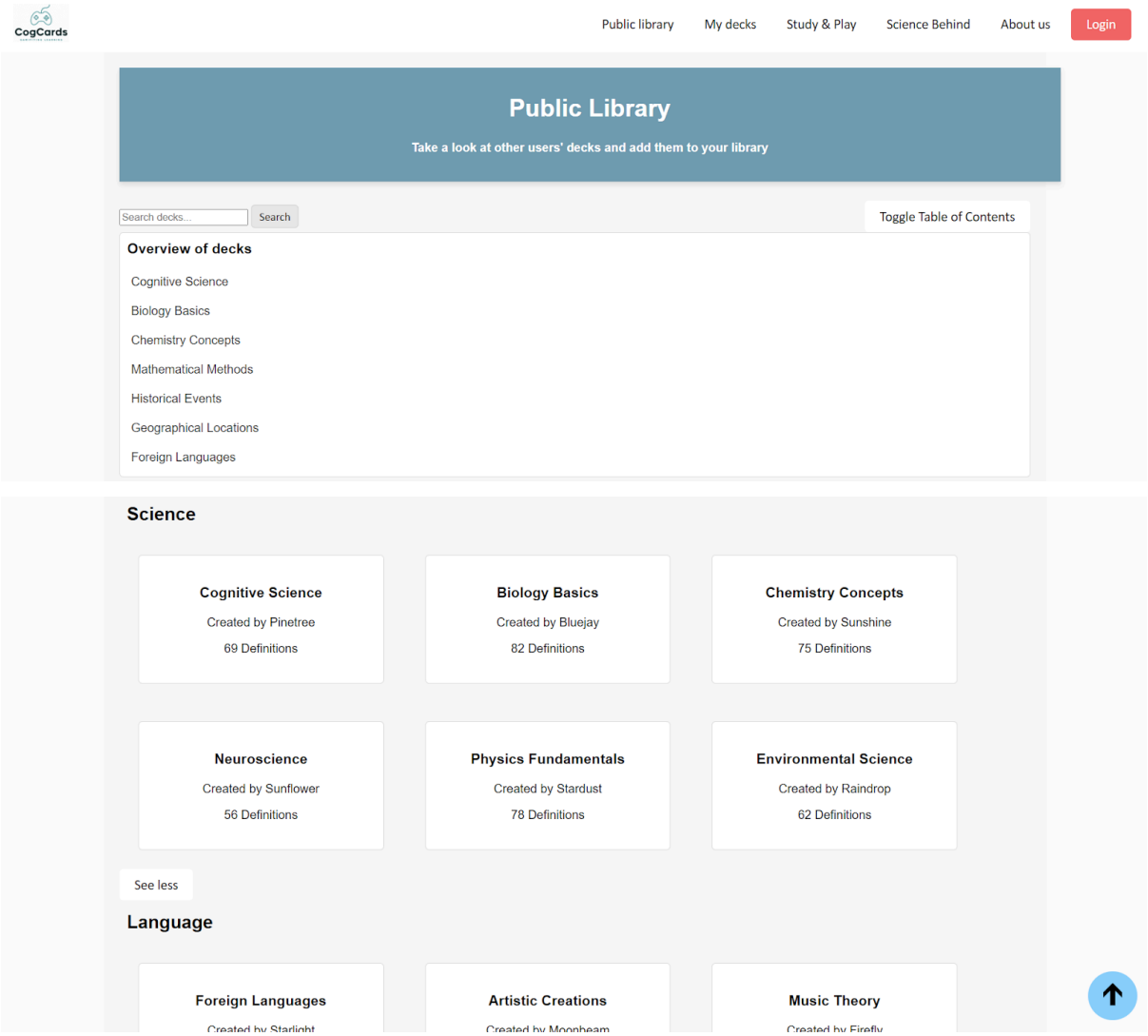


Image 6: The image displays a webpage from a flashcards website's public library section. It features a clean, organised layout with categories for different subjects such as Science, Biology Basics, Chemistry Concepts, and more. Each category is represented by a clickable box with the subject title and the creator's attribution. This image is relevant as it showcases the educational resources available on the website, highlighting the variety of topics that users can explore to enhance their learning experience.

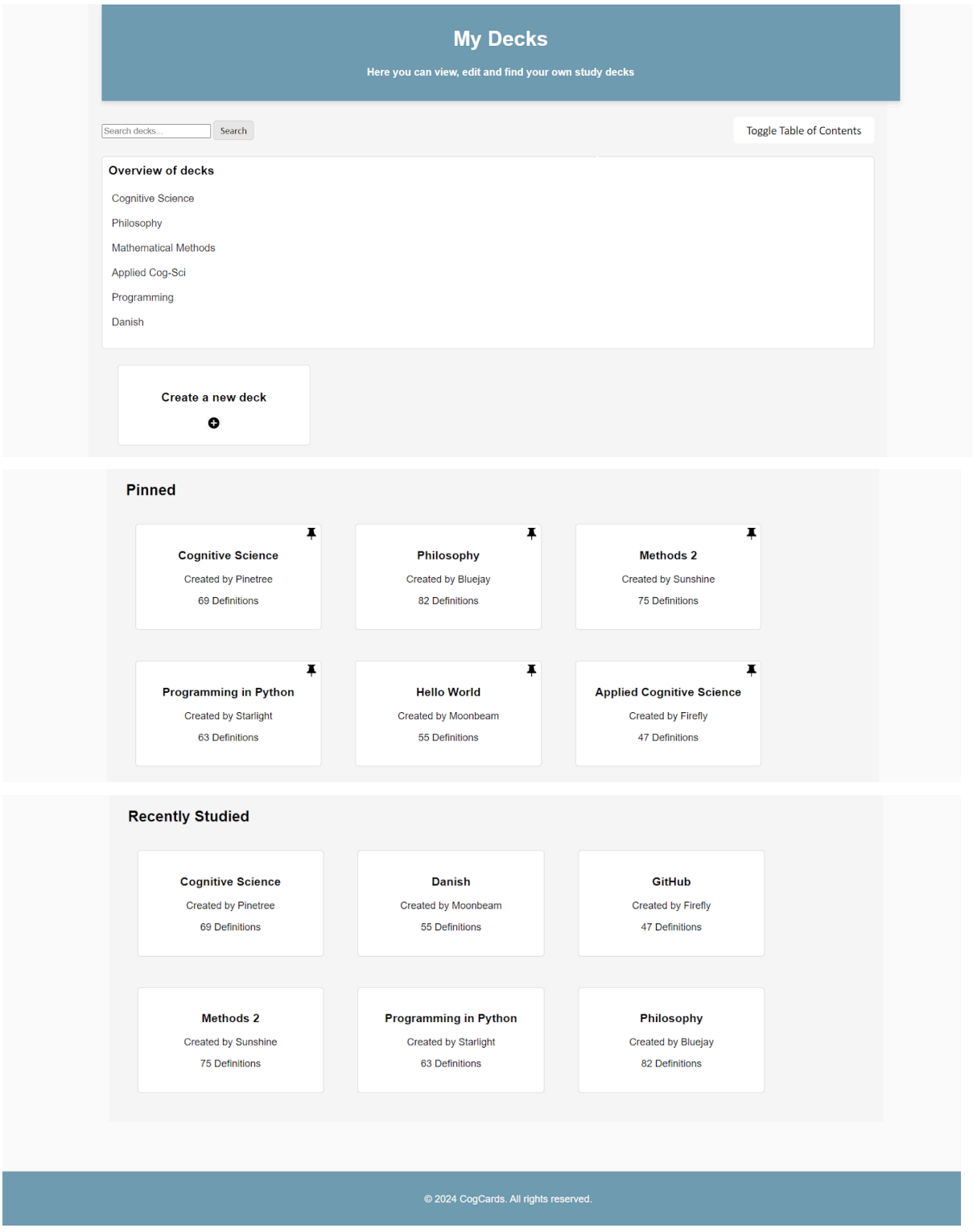


Image 7: The image displays a webpage from the “My Decks” section of a flashcards website. It shows an organised layout with various decks categorised under ‘Pinned’, ‘Recently Studied’, and ‘Created’. Each deck is represented by a card that includes the subject name such as ‘Cognitive Science’, ‘Philosophy’, or ‘Methods 2’. This image demonstrates how users can categorise and access their study materials efficiently, highlighting the website’s functionality in aiding learning and revision.

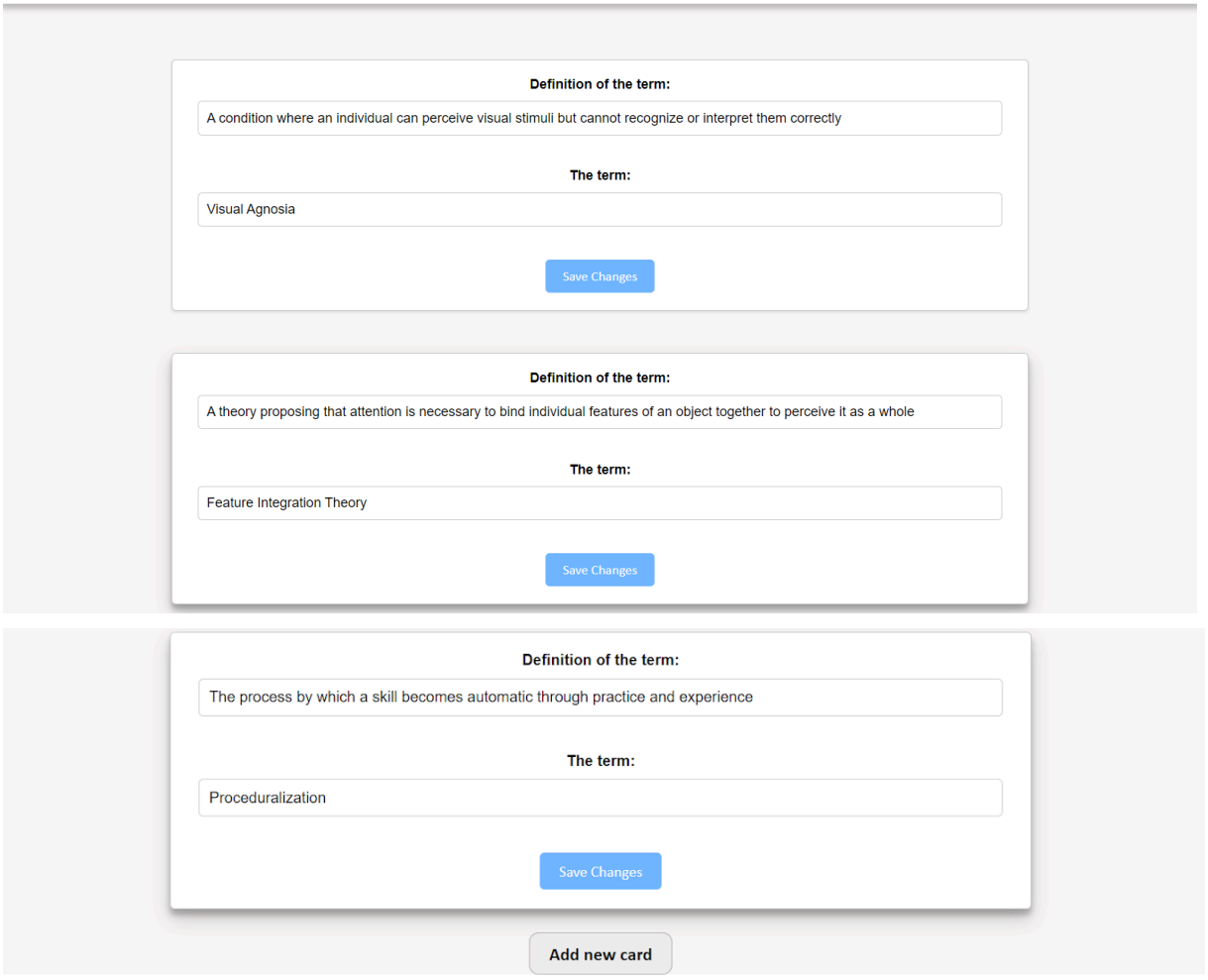


Image 8: The image displays a user interface from a flashcards website, specifically showing three flashcards from a deck titled “Cognitive Science.” Each card features a term at the top, followed by the definition of the term and an option to see changes. The first card presents the term “Visual Agnosia” with its definition stating it is a condition where an individual can perceive visual stimuli but cannot interpret them correctly. The second card shows the term “Feature Integration Theory,” defined as a theory proposing that attention is necessary to bind individual features of an object together to perceive it as a whole. The third card has the term “Proceduralization,” with its definition describing it as the process by which a skill becomes automatic through practice and experience. This image is relevant for illustrating how digital flashcards can be used for studying complex subjects like cognitive science, providing clear and concise definitions for key terms in an easily accessible format.

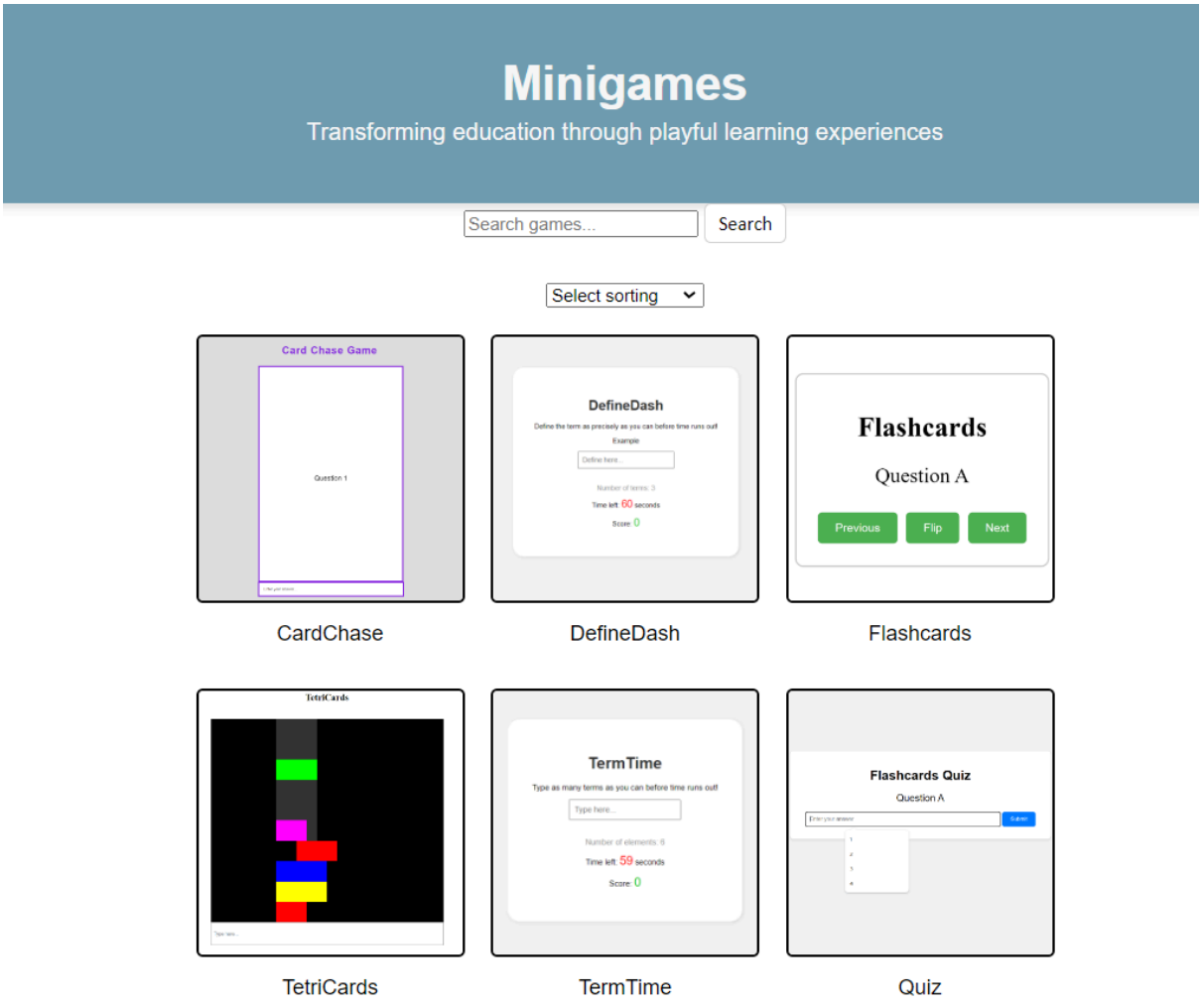


Image 9: The image displays a section of a flashcards website dedicated to “Minigames,” which are designed to transform education through playful learning experiences. There are six minigame options presented in a grid format, each with a unique name and visual representation. The games include “Card Chase,” “DefineDash,” “Flashcards,” “TetriCards,” “TermTime,” and “Quiz.” Each game’s graphic is encased in a white box with the game’s title below it. The overall layout is clean and user-friendly, suggesting an engaging way to learn and memorise information through interactive challenges.

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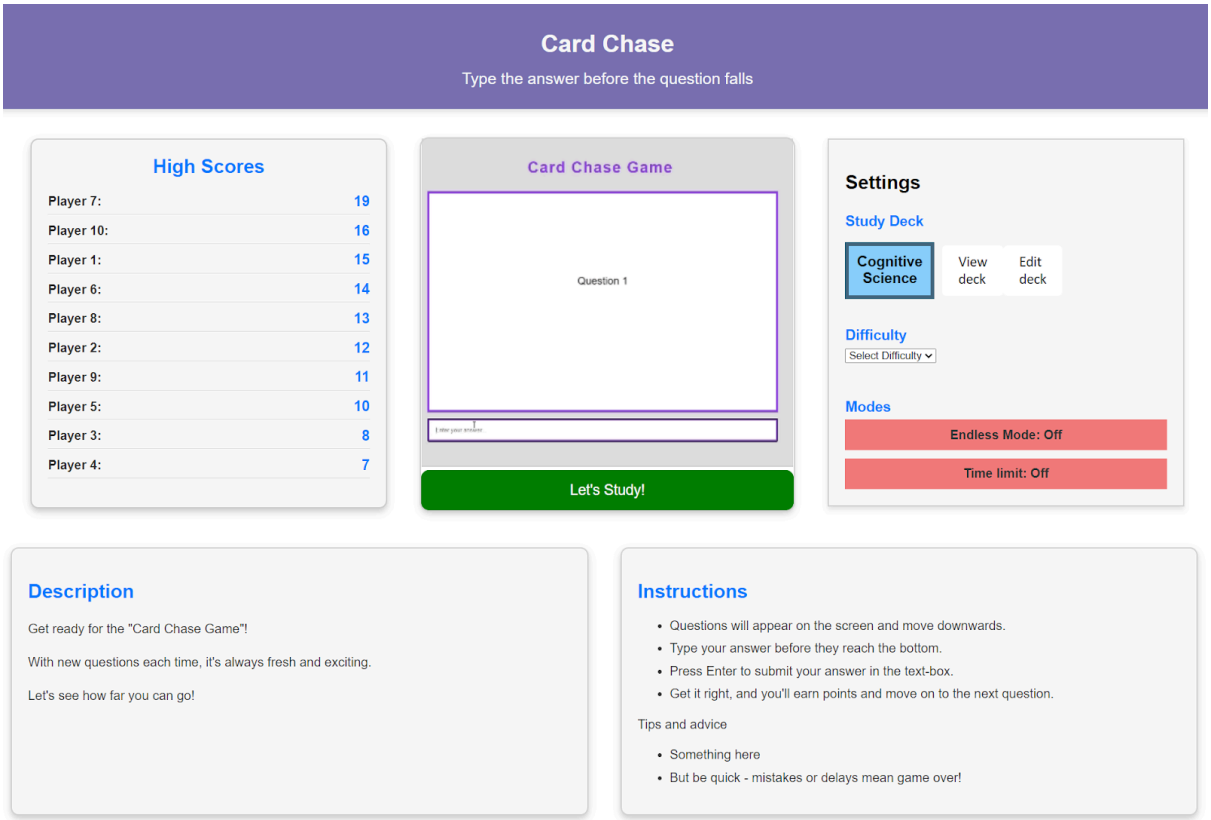


Image 10: The image displays an interface from a flashcards website featuring the “Card Chase Game.” The game is designed to enhance cognitive skills by challenging players to type answers before questions fall off the screen. The left side of the interface shows a leaderboard with ‘Player 1’ at the top, having scored 19 points. In the center, there is a purple card with ‘Question 1’ written on it, indicating where questions will appear during gameplay. On the right side, there are game settings that allow users to select difficulty, edit their deck of cards, and toggle endless mode or time limit options. Below these settings is a green button labelled “Let’s Study!” which presumably starts the game. Instructions for playing are provided below this button, explaining that cards will appear and move downwards, and players must type their answers in a box to score points. This interactive learning tool combines quick thinking with knowledge recall in an engaging format.

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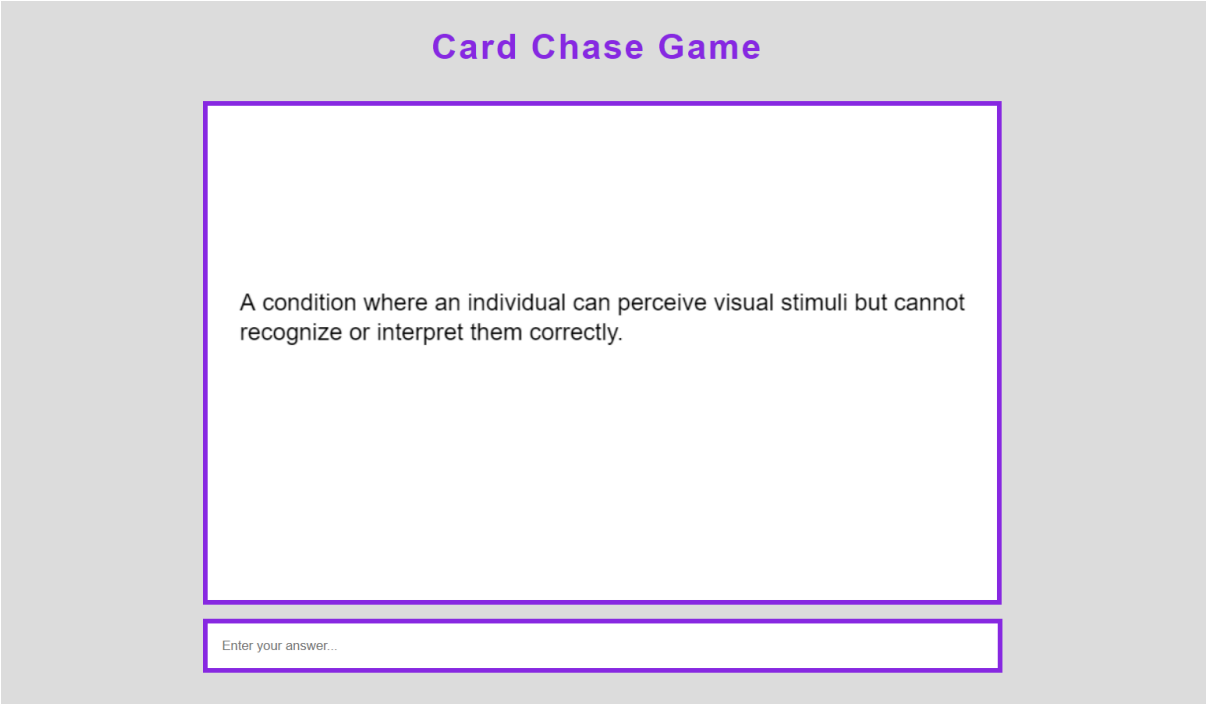


Image 11: The image depicts a screenshot of the “Card Chase Game” from a flashcards website. In the image, there is a purple-bordered card with the title “Card Chase Game” at the top. The card contains a definition that states, “A condition where an individual can perceive visual stimuli but cannot recognize or interpret them correctly.” Below the definition, there is an interactive element prompting the user to “Enter your answer…” This shows that the minigame involves typing in responses related to the provided definitions.

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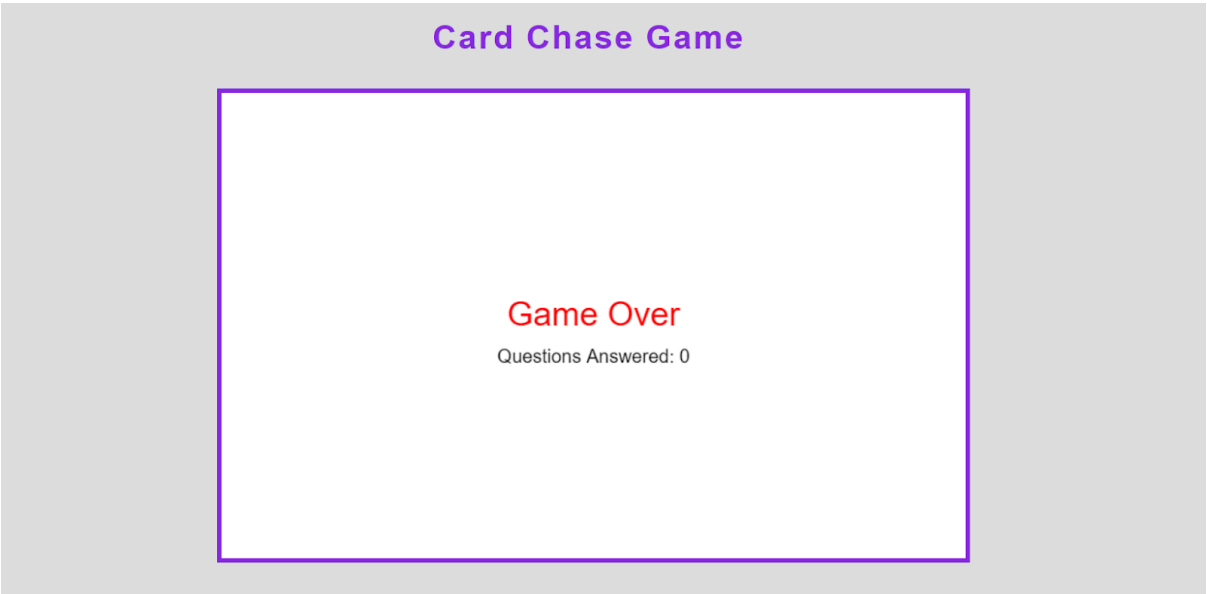


Image 12: The image displays a screen from a game titled “Card Chase Game.” The central part of the image shows the text “Game Over” in red, indicating that the game has ended. Below this, there is another line of text stating “Questions Answered: 0,” which suggests

that no questions were answered correctly during the gameplay. The screen is relevant as it indicates the end of a round or attempt at this game and provides feedback on the player's performance.

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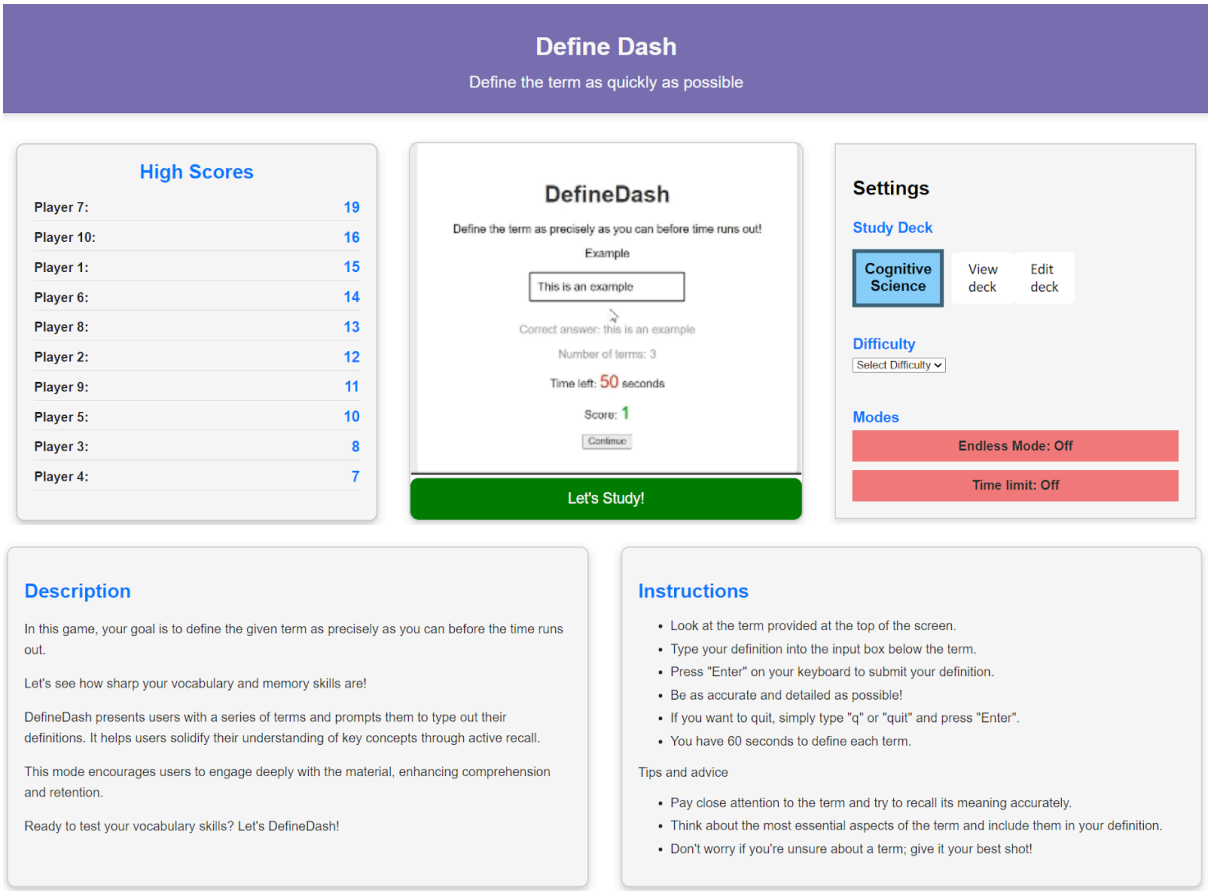


Image 13: The image depicts a minigame from a flashcards website called "Define Dash." In this game, players are presented with terms and must quickly provide accurate definitions. The goal is to test vocabulary skills and comprehension. Players type their definitions within a time limit, aiming for precision.

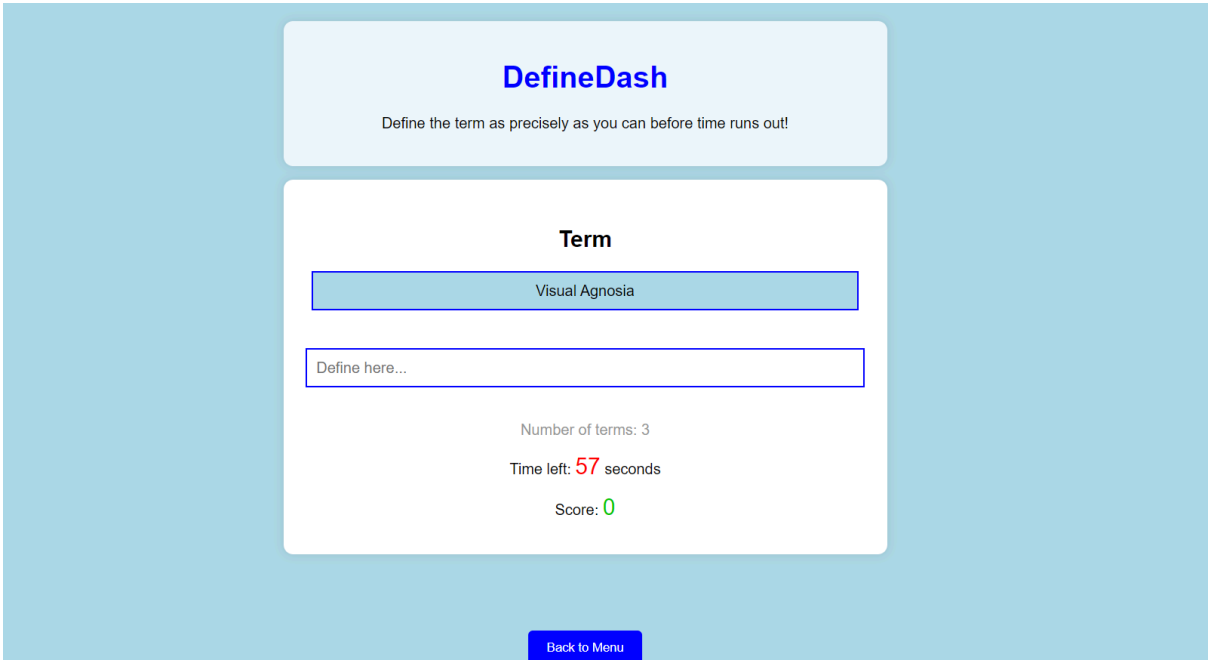


Image 14: The image depicts a minigame from a flashcards website called “Define Dash.” In this game, players are presented with terms and must quickly provide accurate definitions. The goal is to test vocabulary skills and comprehension. Players type their definitions within a time limit, aiming for precision.

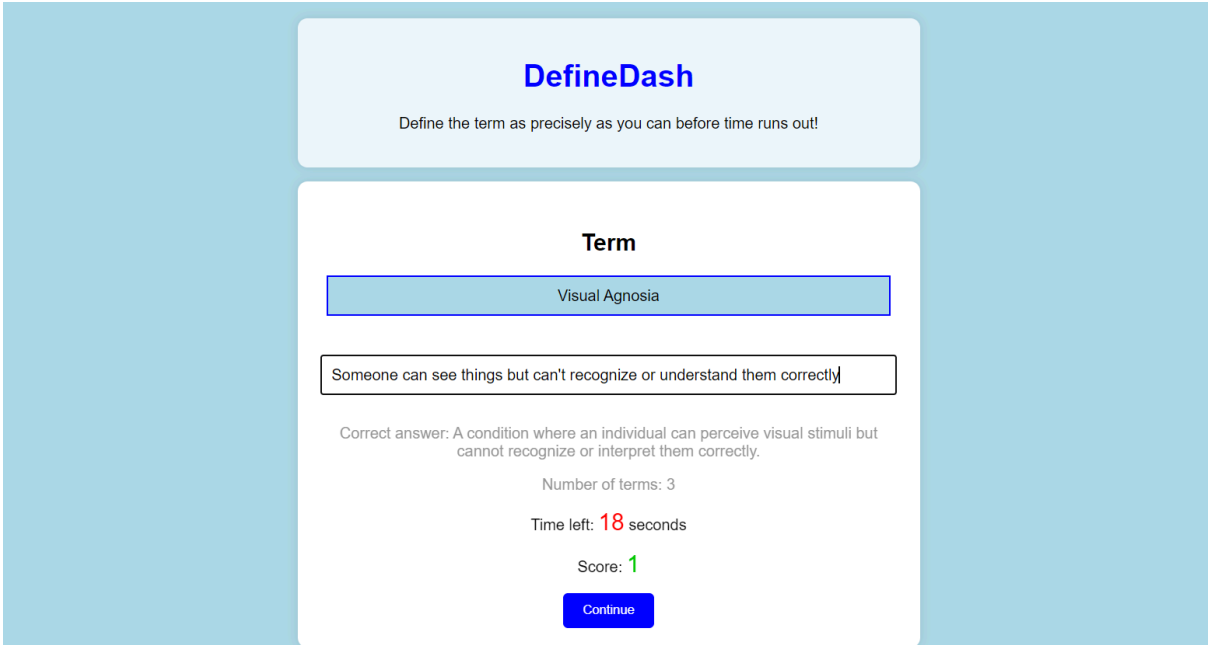


Image 15: The image depicts a screenshot from a flashcards website called “DefineDash.” In this minigame, the objective is to define terms as precisely as possible before time runs out. The term presented is “Visual Agnosia.” Players input their definitions, and the correct answer is provided. The game includes a timer (18 seconds remaining), a score counter (currently at 1), and buttons for continuing or returning to the main menu.

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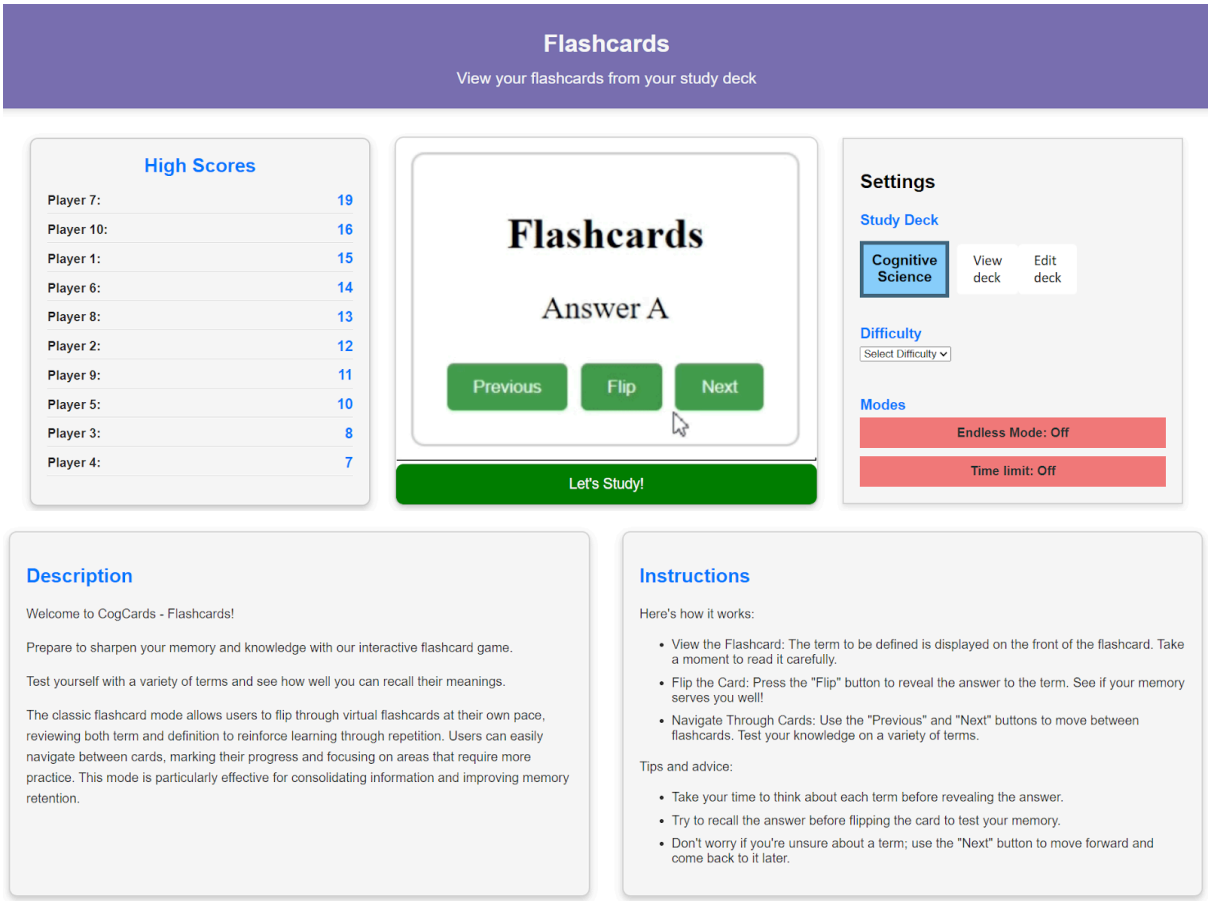


Image 16: The image depicts a screenshot from a flashcards website called “CogCards.” In this minigame, users can view flashcards from their study deck. The central panel displays flashcards with buttons for “Previous,” “Flip,” and “Next,” allowing users to navigate through terms. On the right, there are settings options for category, difficulty, shuffle, and timed mode. The left side shows a scoreboard with player scores. Below the scoreboard, a welcome message explains the purpose of CogCards: to sharpen memory and knowledge through interactive flashcards.

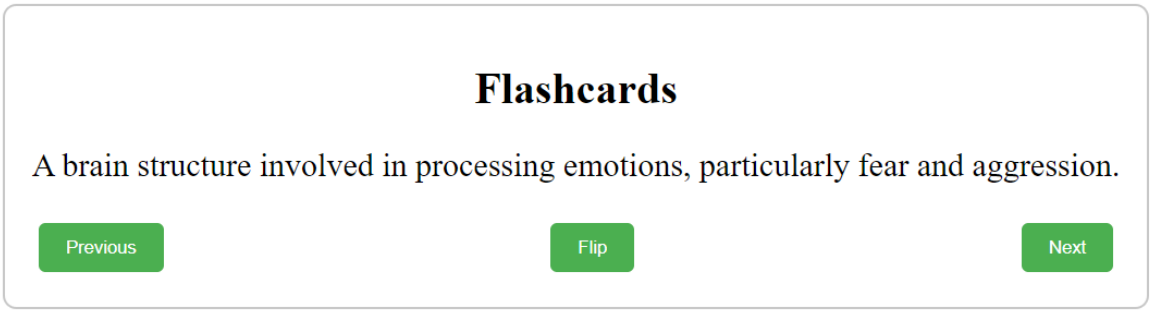


Image 17: The image shows a flashcard with the text: “A brain structure involved in processing emotions, particularly fear and aggression.” This likely belongs to an educational minigame or study tool. Users can navigate between flashcards using the “Previous,” “Flip,” and “Next” buttons.

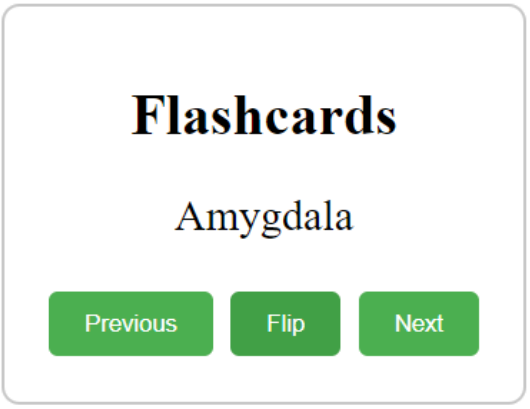


Image 18: The image displays a user interface from a flashcards website, specifically showing a single flashcard with the title “Flashcards” at the top in bold black font. Below the title, there is another word “Amygdala” which is likely the subject or topic of this particular flashcard. There are three buttons presented below: two green buttons on either side labelled “Previous” and “Next,” and one in the center labelled “Flip,” showing that users can navigate through different cards or flip to see more information on the current card.

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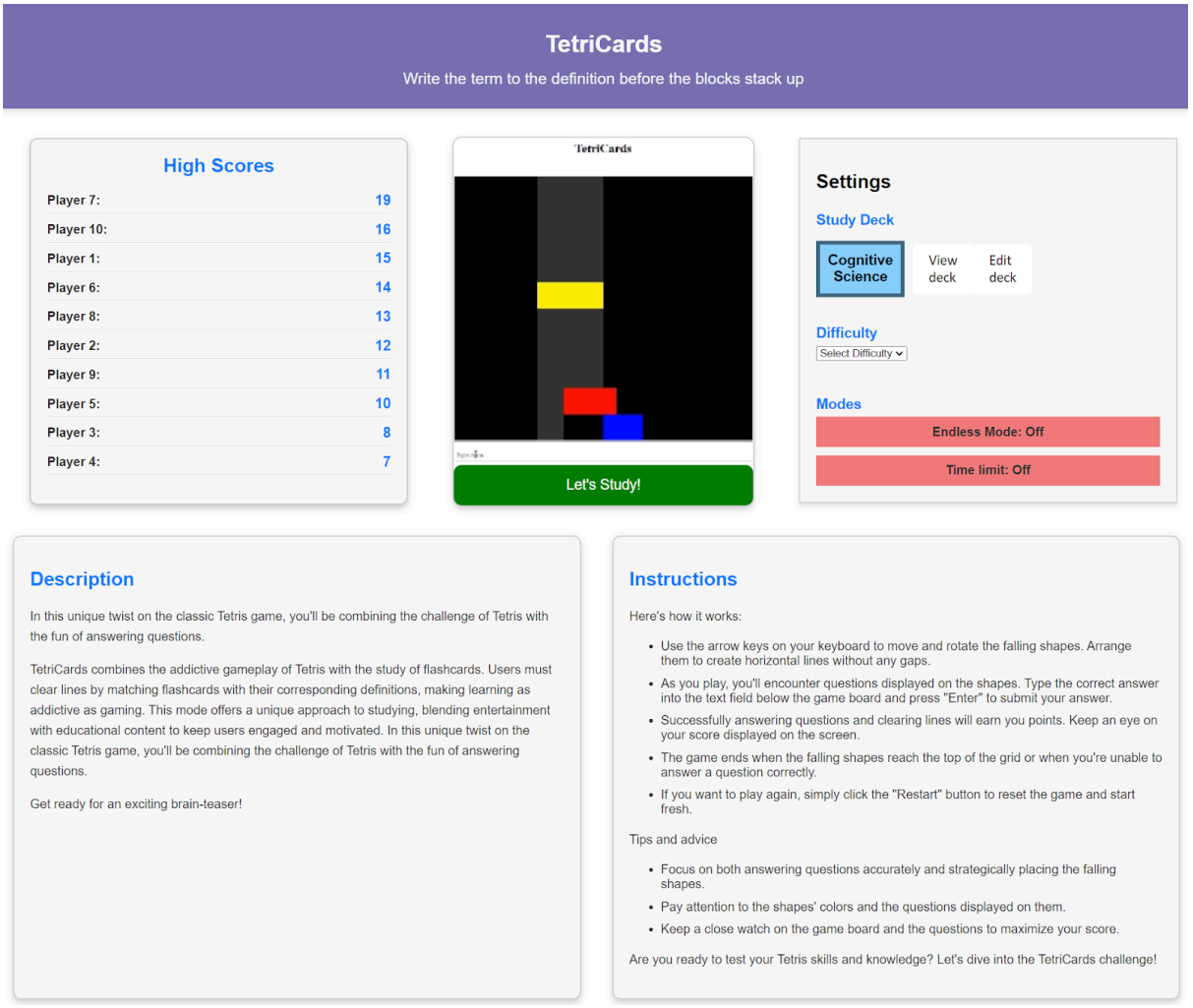


Image 19: The image shows a screenshot of a minigame from a flashcards website called “TetriCards.” In this game, players combine the challenge of Tetris with answering questions. The game area resembles the classic Tetris grid, with coloured blocks stacking up. Players must write terms to define before the blocks reach the top. As they play, questions are displayed on the falling shapes, and players type the correct answers. Successfully answering questions and clearing lines earns points.





Image 20: The image displays a stack of variously coloured blocks arranged in a vertical column against a plain background. The inclusion of an input field labelled “Type here…” shows that the minigame involves typing definitions related to the flashcard content, adding an educational twist to block-stacking gameplay.

Image 21: The image displays the minigame: “TetriCards” indicating that the game is over. The top section of the screen has a red background with the text “Game Over” in pink letters. At the bottom of the image, there’s an input box with placeholder text “Type here…” which implies that the user should type definitions related to the flashcard content.

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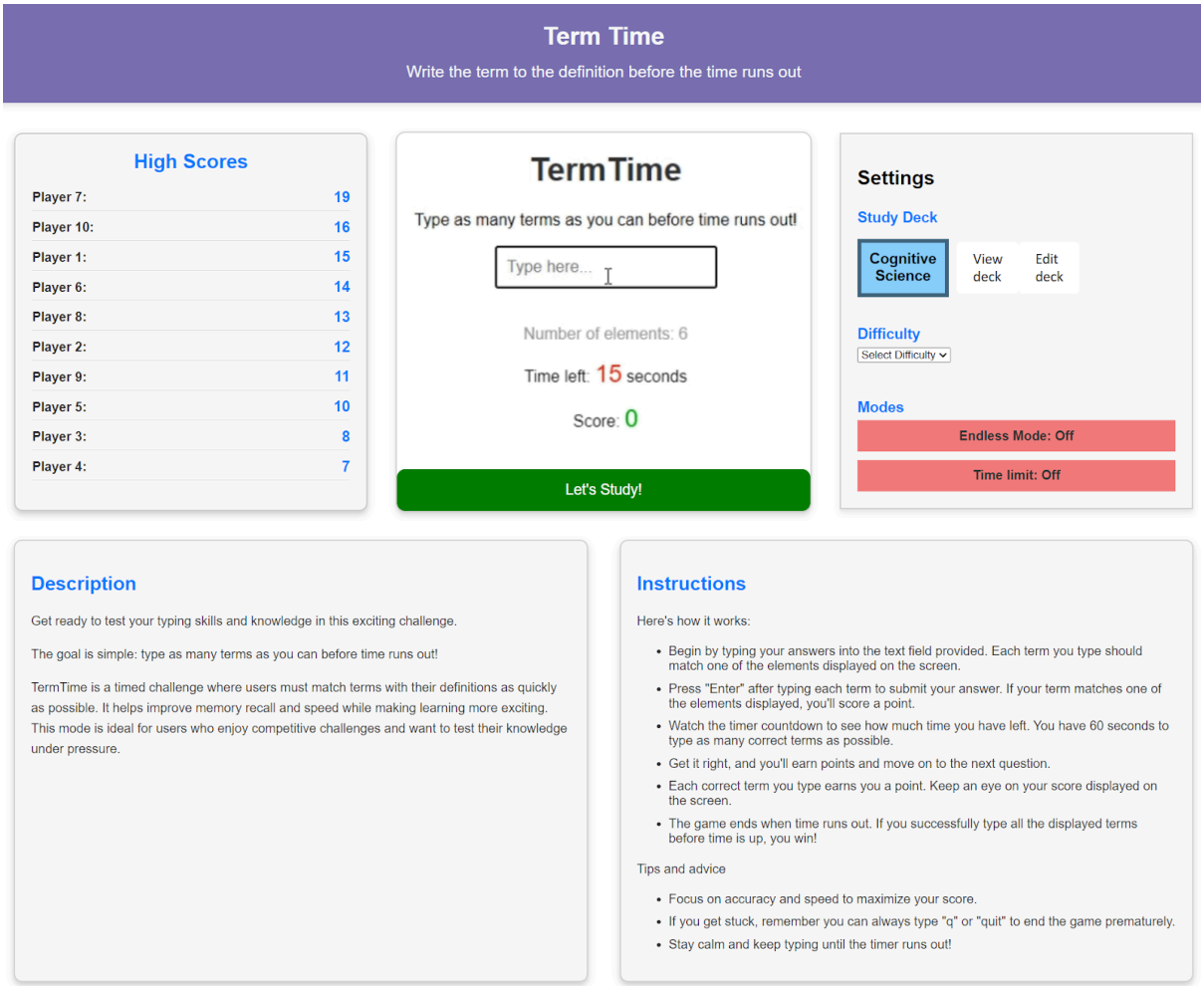


Image 22: The image shows a screenshot of a minigame titled “Term Time.” In this game, players must type as many terms as they can before time runs out. The interface includes a scoreboard, a text input field, and settings for study mode.

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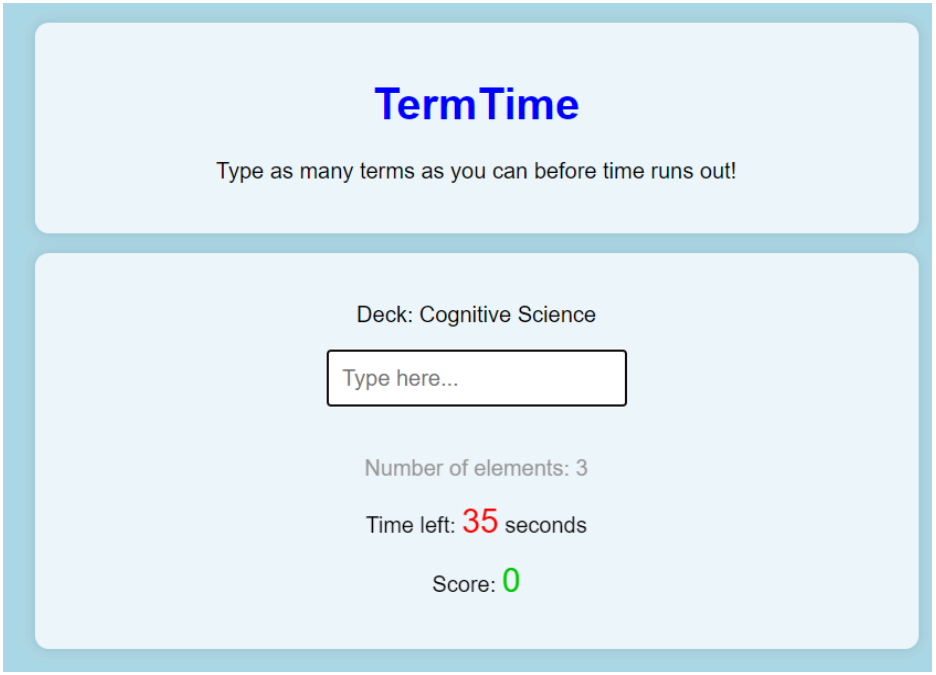


Image 23: The image shows a screenshot of a minigame from a flashcards website titled "Term Time." In this game, players must type as many terms as they can before the time runs out. The interface includes a scoreboard, a text input field, and settings for study mode.

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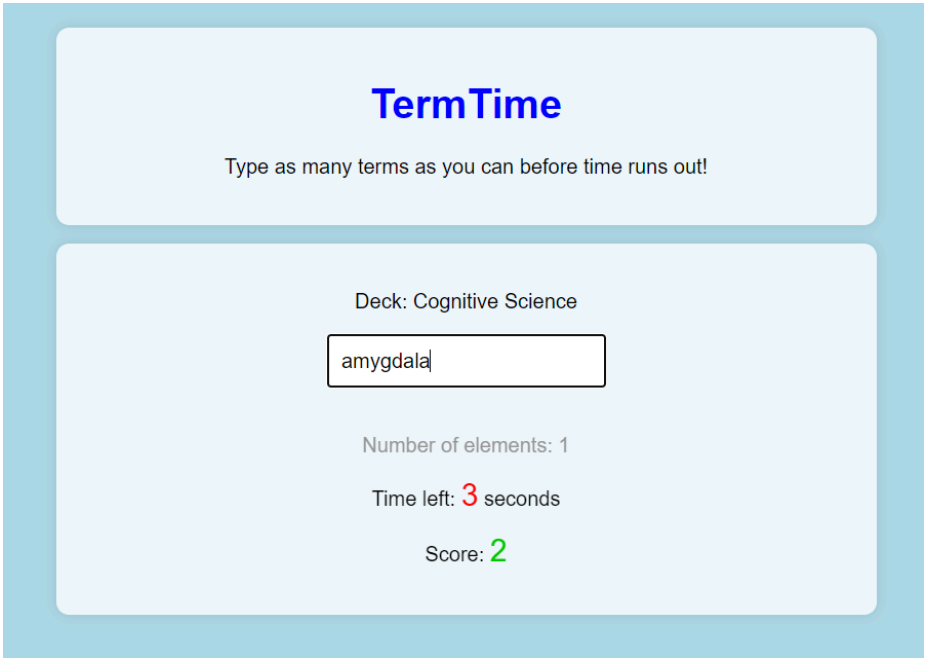


Image 24: The image shows a screenshot of a minigame called "TermTime" from a flashcards website. In this game, players must type as many terms as possible before the time runs out. The current deck selected is "Cognitive Science," and the term displayed is "amygdala." There is only one element in the deck, with 3 seconds left on the timer, and the player has scored 2 points.

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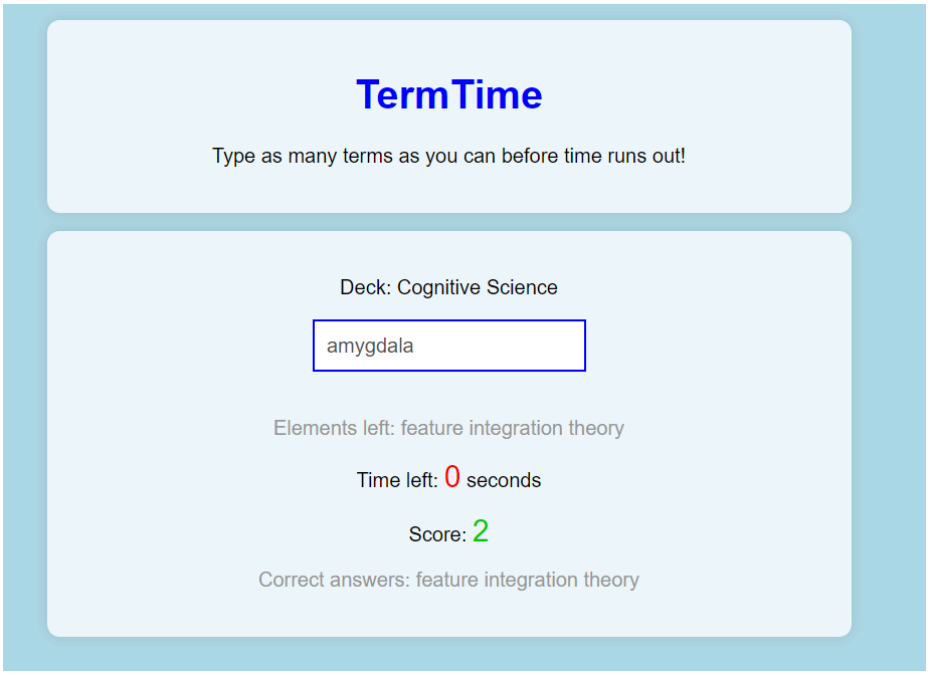
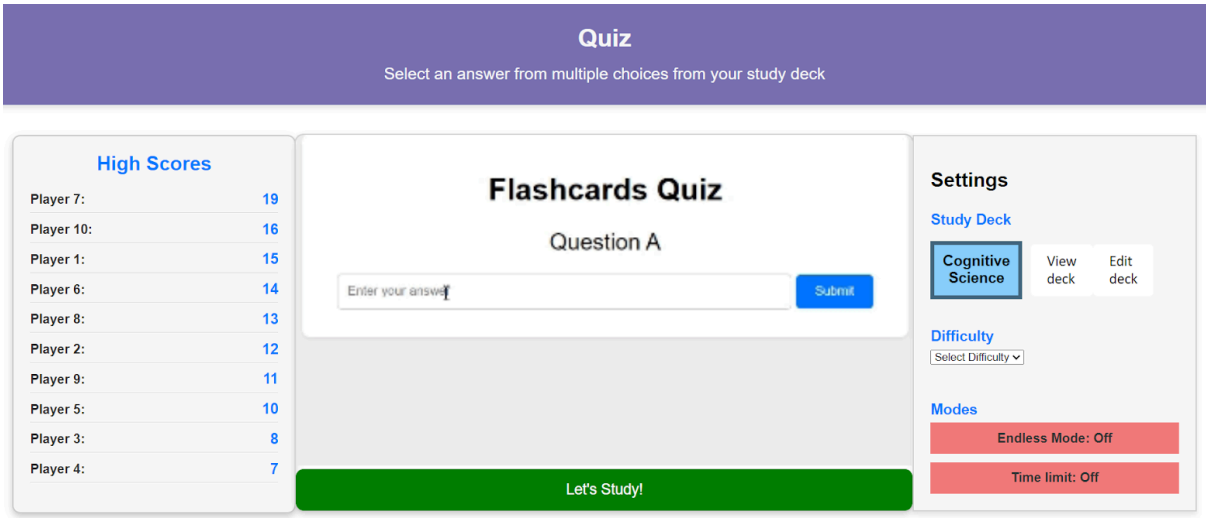


Image 25: The image displays a screenshot of a minigame from a flashcards website called "TermTime." In this game, players must type as many terms as they can before the time runs out. The current deck selected is "Cognitive Science," and the term displayed is "amygdala." The timer shows 0 seconds left, and the player has scored 2 points. The last remaining elements are revealed as the time is up in this case revealing the answer: "feature integration theory".

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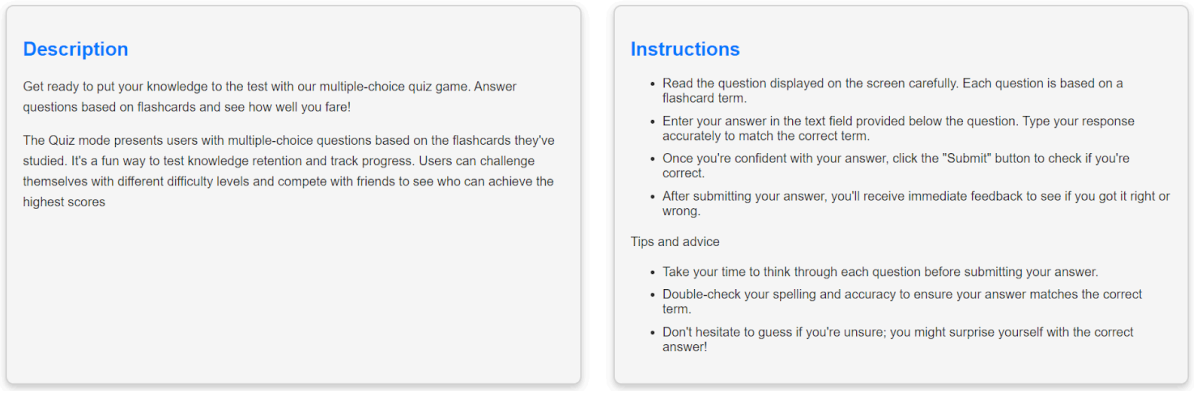


Image 26: The image displays a screenshot of a minigame called “Flashcards Quiz” from a flashcards website. In this quiz, players are presented with multiple-choice questions based on the flashcards they’ve studied. The interface includes a scoreboard on the left, showing scores for ‘Player 1’ through ‘Player 4.’ On the right side, users can select their study deck (such as “Cognitive Science”), toggle difficulty levels, and choose between endless mode options. The instructions encourage players to test their knowledge and track progress by answering questions accurately.

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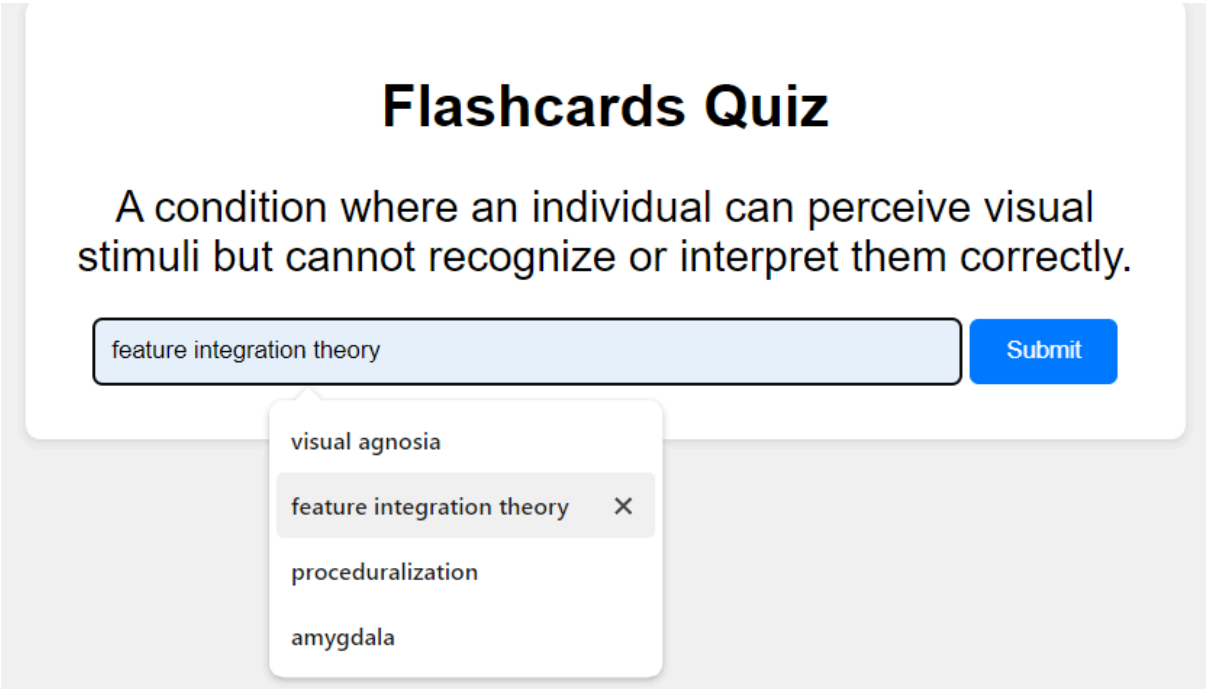


Image 27: The image displays a screenshot of a minigame called “Flashcards Quiz” from a flashcards website. In this quiz, players are presented with a question related to visual perception: “What is the condition where an individual can perceive visual stimuli but cannot recognize or interpret them correctly?” The answer options include “visual agnosia,” “feature integration theory,” “proceduralization,” and “amygdala.” The correct answer, “visual agnosia,” is highlighted, ready for submission. Players can test their cognitive science knowledge and track their progress through this interactive quiz!

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The Science Behind CogCards

Cognitive Science

CogCards utilizes effective learning techniques like spaced repetition and mnemonics, fostering improved memory retention. Through gamification and diverse flashcard categories, it offers an engaging user experience with seamless integration across devices. However, potential overreliance may impede critical thinking, while ethical concerns such as addiction risk and reinforcement of extrinsic motivation arise.

Cognitive biases such as the illusion of explanatory depth, as noted by (Rozenblit & Keil, 2002), suggest a potential weakness in relying solely on flashcards. Our aim is to address this by integrating gamification and personalized learning techniques to optimize memory retention and overcome cognitive biases, ultimately improving our learning platform's effectiveness.



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Flashcard Learning

Flashcard learning is a popular study method that involves reviewing information through flashcards. Research suggests that spaced repetition enhances flashcard effectiveness by promoting long-term memory retention. Studies also investigate the impact of flashcard design, spacing intervals, and mnemonic techniques on memory retrieval and learning efficiency (Saatz & Kienle, 2013).



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Gamifying Learning

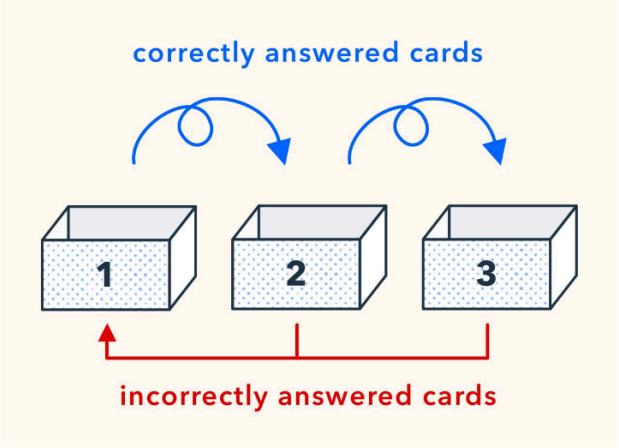
Gamification involves incorporating game elements, such as rewards, challenges, and progression systems, into educational activities. Research on gamifying learning demonstrates its potential to increase student engagement, motivation, and learning outcomes (Subhash & Cudney, 2018). Studies explore the design and implementation of game-based learning systems, emphasizing adaptivity and personalized feedback to enhance learning experiences.



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The Leitner System

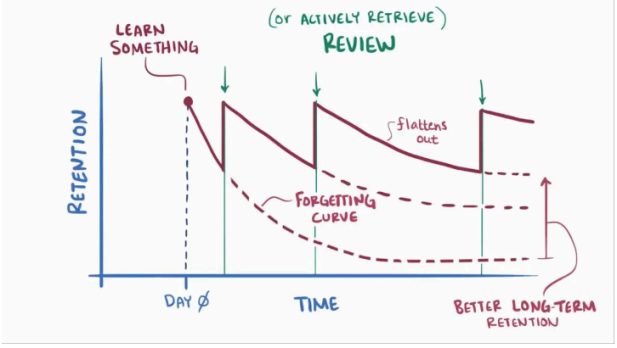
The Leitner System is a spaced repetition technique that involves organizing flashcards into progressively more challenging decks based on recall success. Research on the Leitner System and similar approaches explores their effectiveness in optimizing learning schedules and improving memory retention (Reddy et al., 2016). Other studies investigate memory vocabulary learning strategies and the application of memory techniques in language learning contexts (Benkhenafou & Benkhenafou, 2015).



https://www.pocketprep.com/wp-content/uploads/2023/01/0125_Letiner_Inline.jpg

Spaced Repetition

Spaced repetition is a learning technique that involves reviewing information at increasing intervals over time. Research suggests that spaced repetition optimizes memory retention by capitalizing on the spacing effect, which enhances long-term memory formation (Kang, 2016). Studies on spaced repetition in educational settings highlight its efficacy in promoting efficient and effective learning across various subjects (Dempster, 1989).



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Memory in General

Memory is a complex cognitive process that involves the encoding, storage, and retrieval of information. It encompasses various types of memory, including sensory memory, short-term memory, and long-term memory. Research suggests that memory formation is influenced by factors such as attention, rehearsal, and emotional arousal (Haaman, 2001).



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Understanding Brain, Memory Retention, and Recall Processes

Studies utilizing EEG and fMRI techniques have provided insights into the neural mechanisms underlying memory retention and recall. EEG measures electrical activity in the brain, revealing patterns associated with memory processes (Bäuml & Schlichting, 2014). fMRI, on the other hand, detects changes in blood flow, highlighting brain regions involved in memory tasks.

Research from Edge Hill University explores memory retention and recall processes, shedding light on factors that affect memory performance, such as encoding specificity and context-dependent retrieval (Nowinski & Dismukes, 2005).



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Memory Recall After "Learning by Doing" vs. "Learning by Viewing"

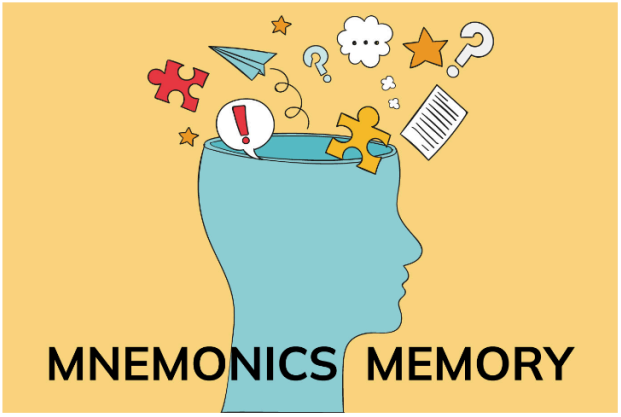
Studies comparing memory recall after active participation ("learning by doing") and passive observation ("learning by viewing") have shown mixed results (Steffens et al., 2015). While some research suggests an enactment benefit, where actively engaging with material enhances memory retention, other studies indicate that the effectiveness of enactment depends on various factors, such as task complexity and individual differences (Steffens, 2007).



https://www.test4u.eu/blog/wp-content/uploads/2015/10/learn_by_doing_3.jpg

Memory Techniques

Various memory techniques, such as mnemonics, visualization, and chunking, can enhance memory encoding and retrieval. Psychology Today discusses strategies for improving memory, emphasizing the importance of rehearsal, organization, and retrieval practice. Additionally, research explores the effectiveness of semantic memory strategies and category learning in enhancing recognition memory (Sekuler & Kahana, 2007).



https://classplusapp.com/growth/wp-content/uploads/2023/05/List-Of-Mnemonics-In-Studies-For-Better-Memory.jpg

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Image 28: The image shows a webpage titled “The Science Behind CogCards.” It explains the cognitive science principles that make flashcards an effective learning tool. Topics covered include cognitive load theory, spaced repetition, active recall, metacognition, and memory techniques. It’s an educational page designed to enhance memory retention and improve learning outcomes through evidence-based strategies. Lastly, the page contains a summary of all the used references throughout the page in alphabetical order.

CogCards

Public library | My decks | Study & Play | Science Behind | About us | 34 | Name Nameson

About CogCards

Contact

Welcome to CogCards

CogCards is an interactive app and website designed to enhance student learning through personalized flashcards and memory techniques. Drawing from research on the effectiveness of flashcards, CogCards offers a unique approach to studying key concepts and terms. With features like synesthetic memory techniques, mini-games, and research-based learning strategies, CogCards transforms the traditional flashcard experience into an engaging and effective learning tool.

Product Details

The frontend product is an interactive website. It offers various learning modes to better match individual user expectations, from standard flashcards viewing, to tetris-like mini-games, which gamify the experience and allow users to study the material by having fun. The website allows users to create their own study content or access other user-generated material via a search tool. The decks can then be modified, shared, exported, deleted and used for studying.

The app consists of four different learning modes in total. First, a traditional-like flashcard viewing based on real-life use of flashcards. Then, an open-answers quiz, which allows the users to test their familiarity with the material by typing out the definitions. Finally, there are two mini-games designed to engage users in the learning process by making it more enjoyable and fun.

Cognitive Science

CogCards utilizes effective learning techniques like spaced repetition and mnemonics, fostering improved memory retention. Through gamification and diverse flashcard categories, it offers an engaging user experience with seamless integration across devices. However, potential overreliance may impede critical thinking, while ethical concerns such as addiction risk and reinforcement of extrinsic motivation arise.

Featured Games

Cardchase

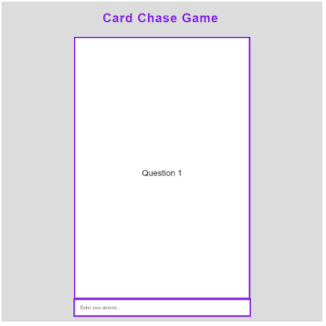
Cardchase is a fast-paced game where users must match flashcards with their corresponding definitions before time runs out. It tests memory recall and helps reinforce learning in a fun and challenging way. Players can compete against the clock to improve their speed and accuracy, making it an exciting way to review key concepts.

Here's how it works:

- Questions will appear on the screen and move downwards.
- Type your answer before they reach the bottom.
- Press Enter to submit your answer in the text-box.
- Get it right, and you'll earn points and move on to the next question.

But be quick - mistakes or delays mean game over!

Let's see how far you can go!



DefineDash

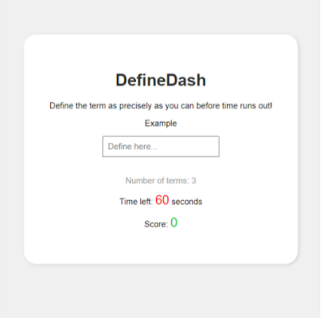
DefineDash presents users with a series of terms and prompts them to type out their definitions. It helps users solidify their understanding of key concepts through active recall. This mode encourages users to engage deeply with the material, enhancing comprehension and retention.

In this game, your goal is to define the given term as precisely as you can before the time runs out.

Tips and advice

- Pay close attention to the term and try to recall its meaning accurately.
- Think about the most essential aspects of the term and include them in your definition.
- Don't worry if you're unsure about a term; give it your best shot!

Ready to test your vocabulary skills? Let's DefineDash!



Flashcards

The classic flashcard mode allows users to flip through virtual flashcards at their own pace, reviewing both term and definition to reinforce learning through repetition. Users can easily navigate between cards, marking their progress and focusing on areas that require more practice. This mode is particularly effective for consolidating information and improving memory retention.

Tips and advice:

- Take your time to think about each term before revealing the answer.
- Try to recall the answer before flipping the card to test your memory.
- Don't worry if you're unsure about a term; use the "Next" button to move forward and come back to it later.

Prepare to sharpen your memory and knowledge with our interactive flashcard game.



TetriCards

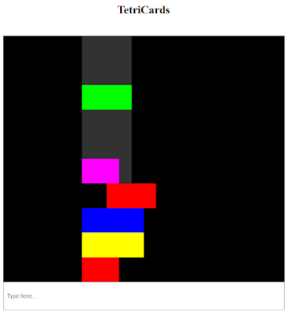
TetriCards combines the addictive gameplay of Tetris with the study of flashcards. Users must clear lines by matching flashcards with their corresponding definitions, making learning as addictive as gaming. This mode offers a unique approach to studying, blending entertainment with educational content to keep users engaged and motivated.

In this unique twist on the classic Tetris game, you'll be combining the challenge of Tetris with the fun of answering questions.

Tips and advice

- Focus on both answering questions accurately and strategically placing the falling shapes.
- Pay attention to the shapes' colors and the questions displayed on them.

Are you ready to test your Tetris skills and knowledge? Let's dive into the TetriCards challenge!



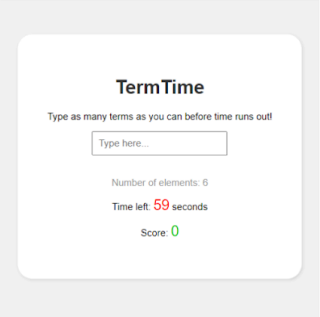
TermTime

TermTime is a timed challenge where users must match terms with their definitions as quickly as possible. It helps improve memory recall and speed while making learning more exciting. This mode is ideal for users who enjoy competitive challenges and want to test their knowledge under pressure.

Get ready to test your typing skills and knowledge in this exciting challenge.

The goal is simple: type as many terms as you can before time runs out!

- Begin by typing your answers into the text field provided. Each term you type should match one of the elements displayed on the screen.
- Watch the timer countdown to see how much time you have left. You have 60 seconds to type as many correct terms as possible.
- The game ends when time runs out. If you successfully type all the displayed terms before time is up, you win!



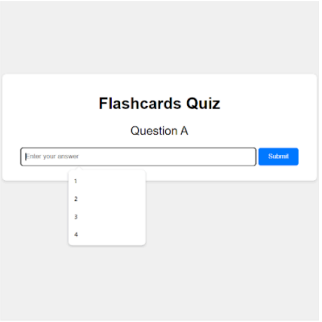
Quiz

The Quiz mode presents users with multiple-choice questions based on the flashcards they've studied. It's a fun way to test knowledge retention and track progress. Users can challenge themselves with different difficulty levels and compete with friends to see who can achieve the highest scores.

Here is how it works:

- Read the question displayed on the screen carefully. Each question is based on a flashcard term.
- Enter your answer in the text field provided below the question. Type your response accurately to match the correct term.
- Once you're confident with your answer, click the "Submit" button to check if you're correct.

Get ready to put your knowledge to the test with our multiple-choice quiz game!



What Our Users Say

"CogCards has been a lifesaver during my exam preparation. The games make studying fun, and I've noticed a significant improvement in my retention of key concepts."

- Maria, University Student

"I love how I can create my own flashcard decks or access decks created by other users. It's made studying so much more efficient!"

- Jonas, College Student

"The mini-games are addictive! I find myself studying for hours without even realizing it."

- Emma, Graduate Student

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Image 29: The image shows an introduction to the platform's purpose and features, emphasising the use of flashcards and memory techniques for learning. Firstly including detailed explanations of various learning modes, including traditional flashcard viewing, open-answer quizzes, and engaging mini-games. Then showing descriptions of specific games offered by CogCards, along with helpful tips for playing. Lastly, the page uses testimonials from satisfied users to highlight the platform's effectiveness.

— — — — —

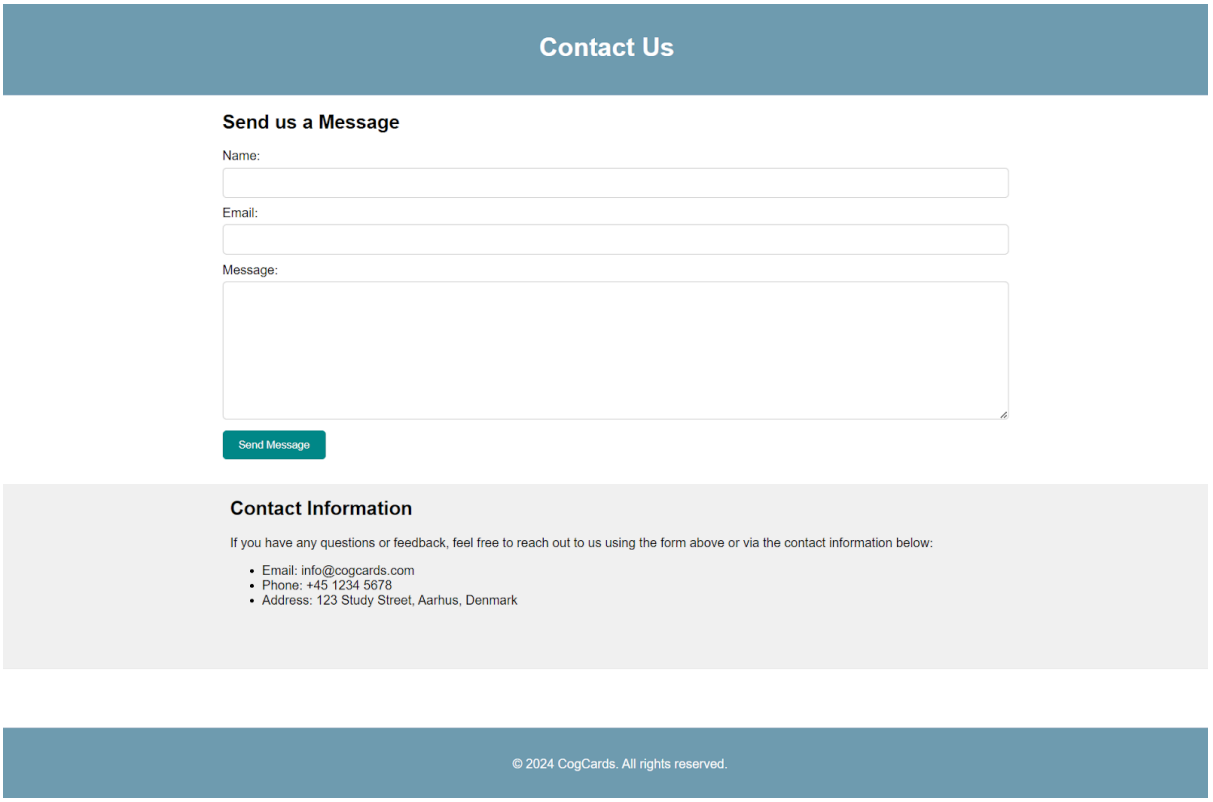


Image 30: The image shows a page design that is simple and user-friendly, ensuring easy navigation for all users, including those who rely on screen readers. The form includes fields for name, email, and message, along with a “Send Message” button. Below the form, essential contact details are listed.

— — — — —

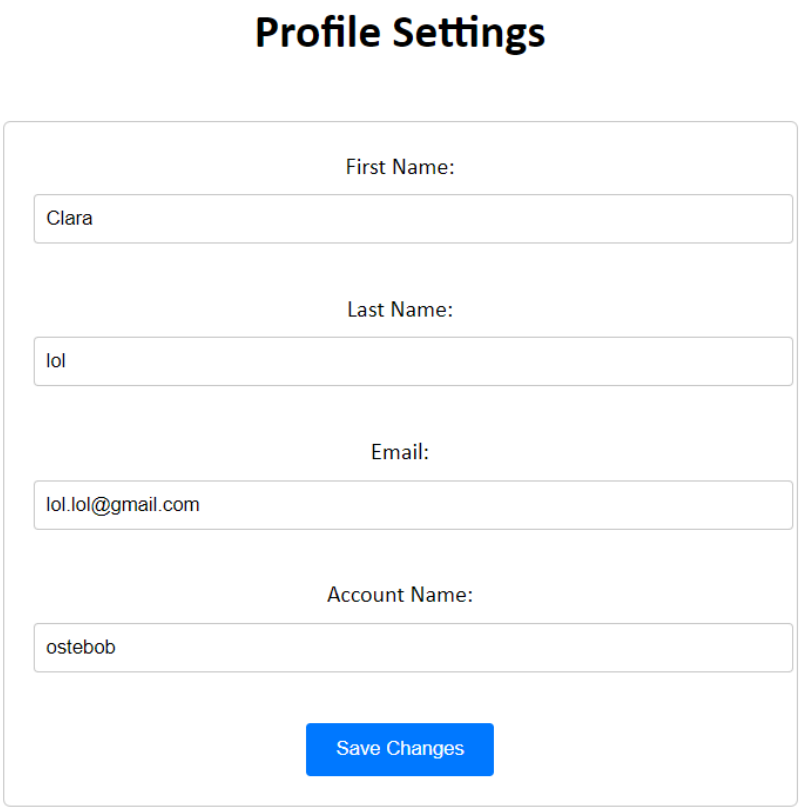


Image 31: The image appears to be a profile settings page from a flashcards website. It includes fields for “First Name” and “Last Name”, with the first name “Clara” already filled in. The “Last Name” field contains the text “lol”. An email address is entered as “lol.lol@gmail.com”, and the account name is given as “ostebob”. Below these fields, there is a button labelled “Save Changes”, indicating that users can update their profile information on this page.

Beta testing results

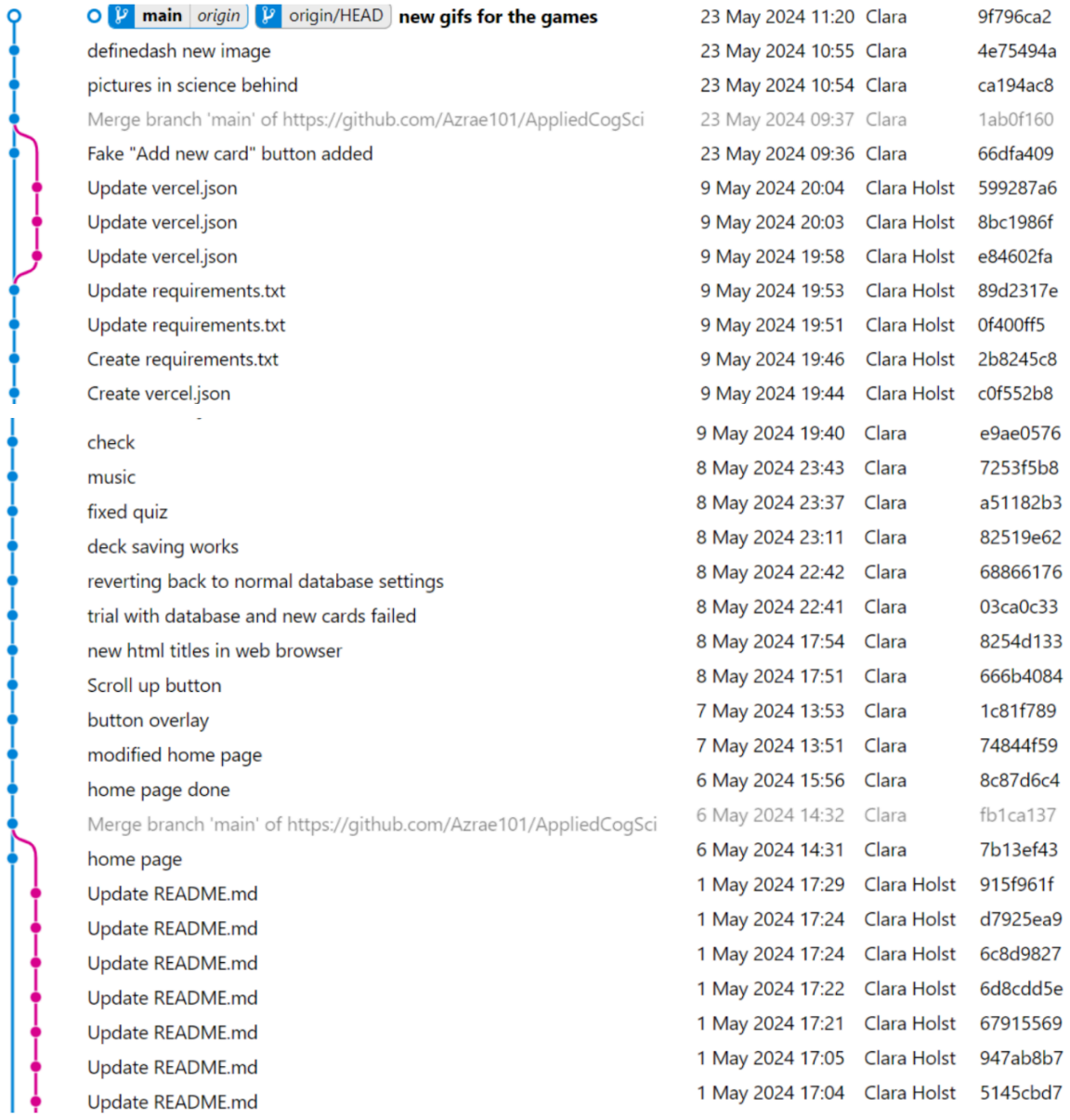
Link to the survey results:

- https://docs.google.com/forms/d/1dei4vQCye4LIUvCcgXveOnNyEGEfK1Kl2GPYWAJ972U/viewanalytics

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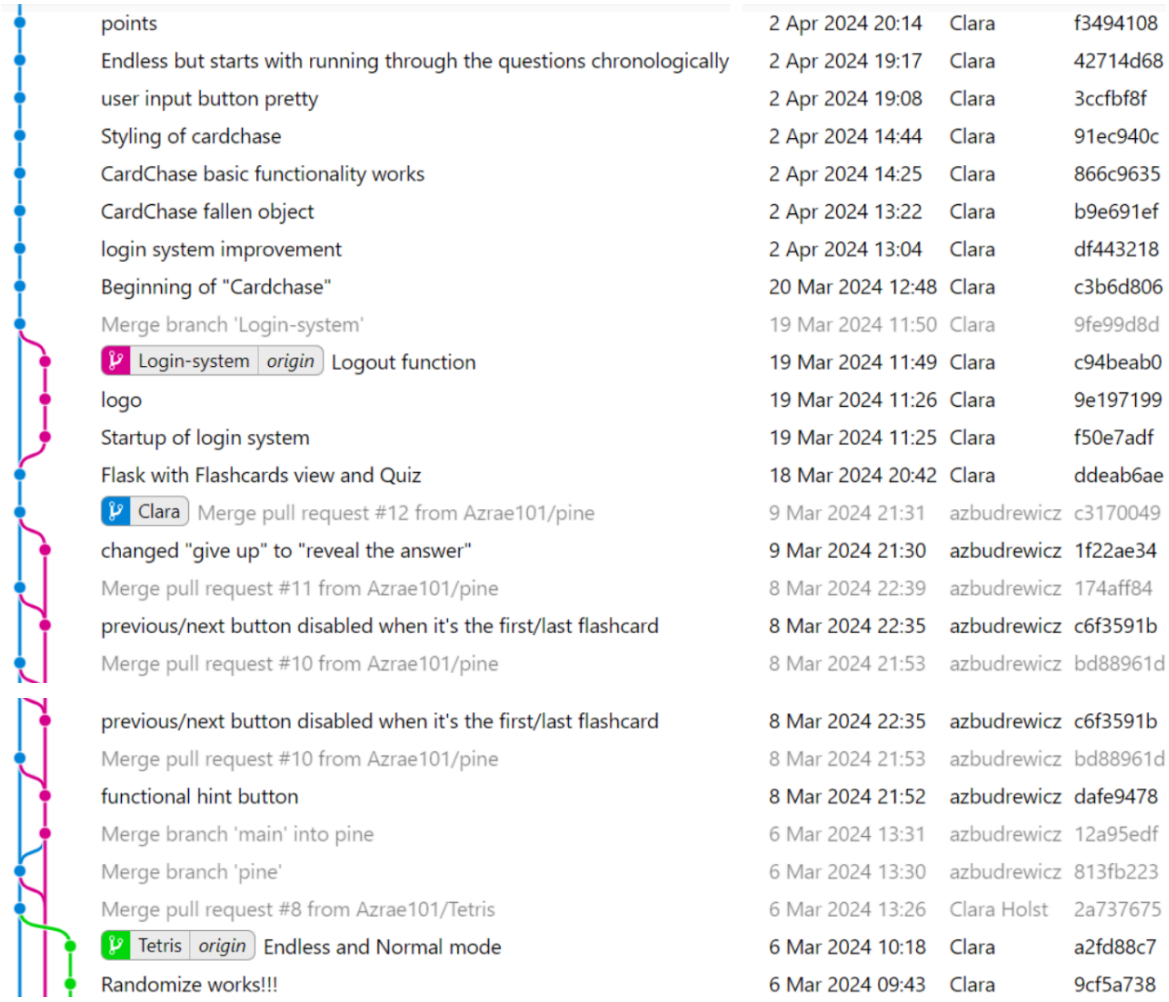
GitHub GitGraph

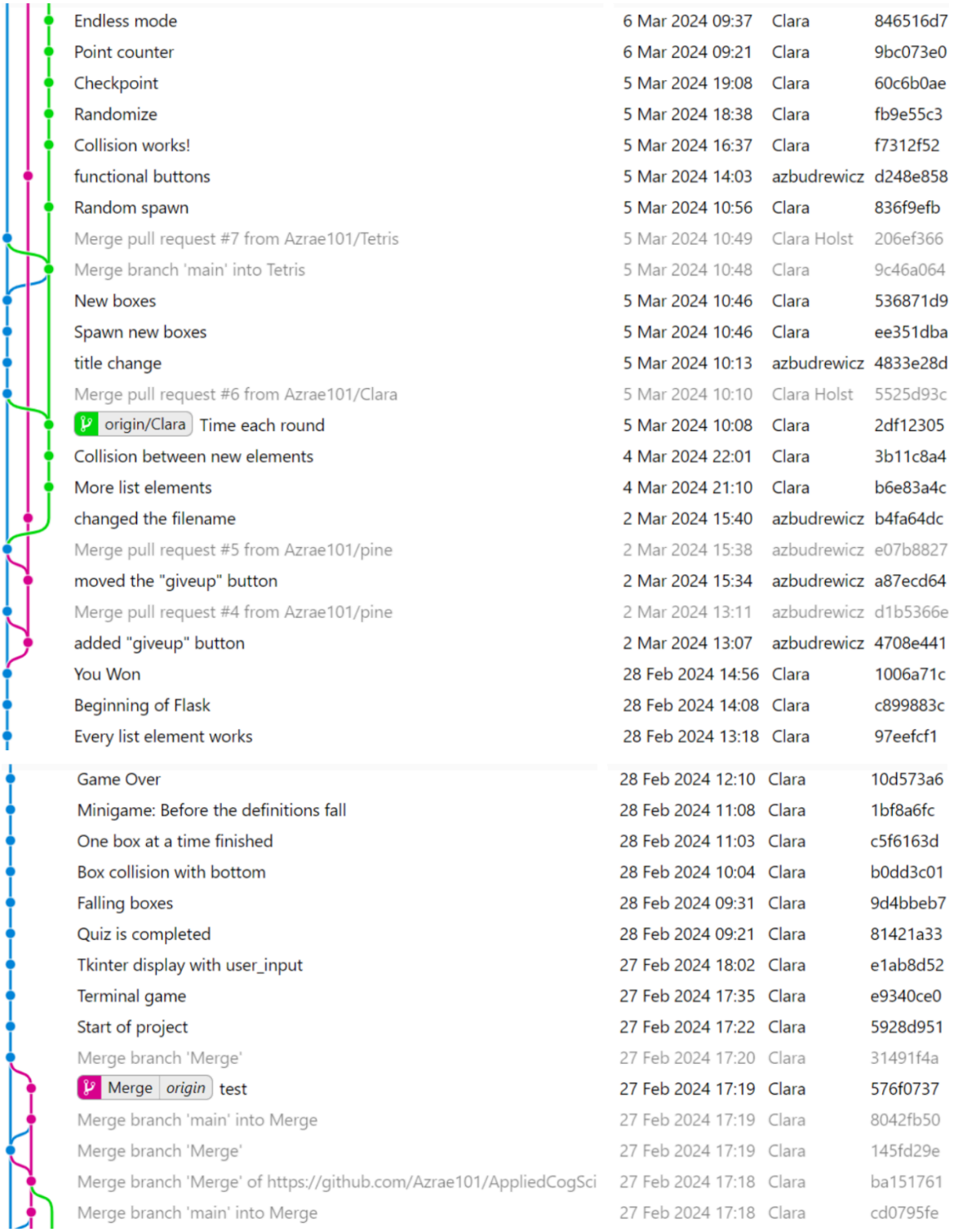
The process of the product development as viewed through commits to GitHub.



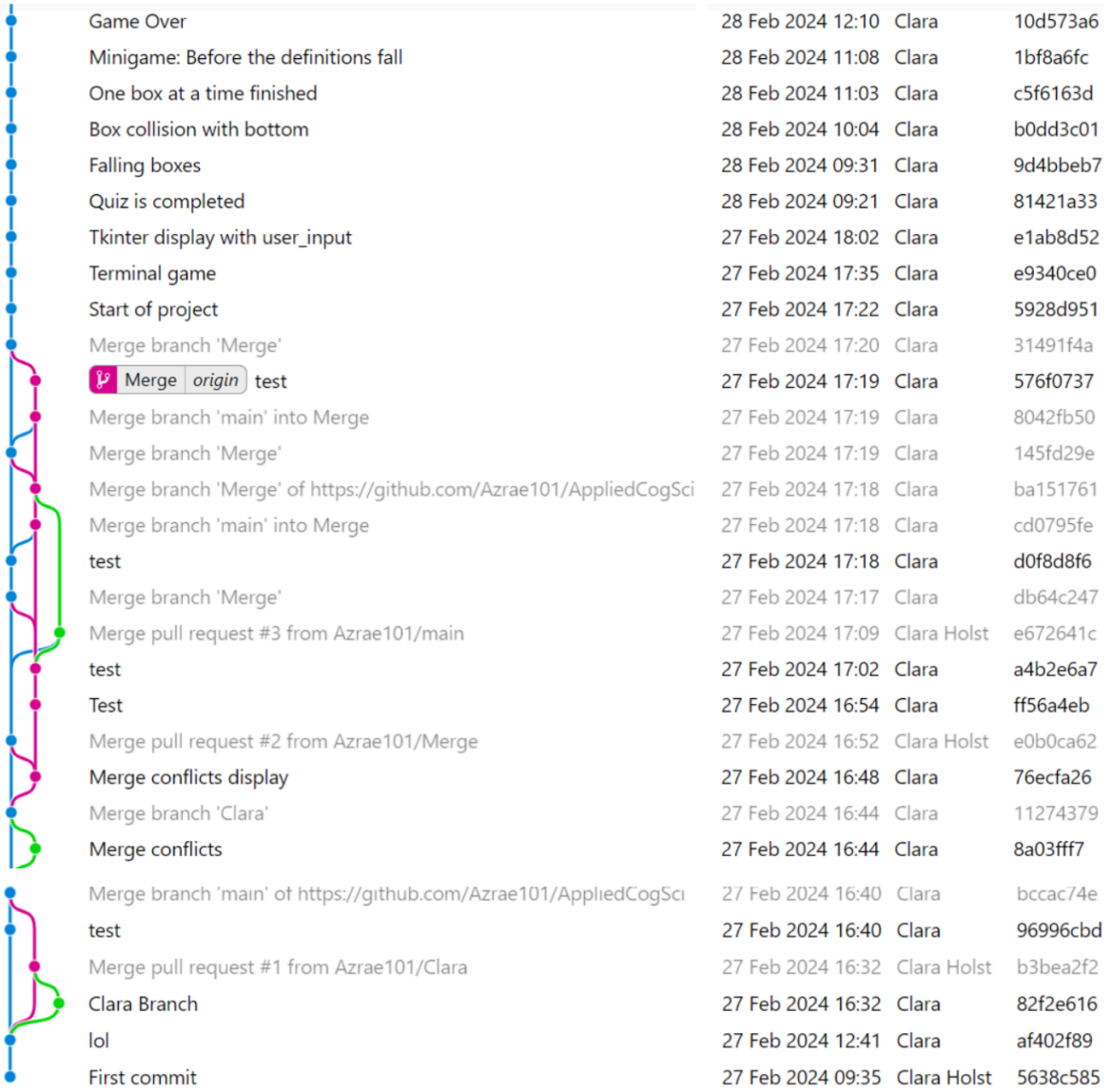
main origin origin/HEAD **new gifs for the games**	23 May 2024 11:20	Clara	9f796ca2
definedash new image	23 May 2024 10:55	Clara	4e75494a
pictures in science behind	23 May 2024 10:54	Clara	ca194ac8
Merge branch 'main' of https://github.com/Azrae101/AppliedCogSci	23 May 2024 09:37	Clara	1ab0f160
Fake "Add new card" button added	23 May 2024 09:36	Clara	66dfa409
Update vercel.json	9 May 2024 20:04	Clara Holst	599287a6
Update vercel.json	9 May 2024 20:03	Clara Holst	8bc1986f
Update vercel.json	9 May 2024 19:58	Clara Holst	e84602fa
Update requirements.txt	9 May 2024 19:53	Clara Holst	89d2317e
Update requirements.txt	9 May 2024 19:51	Clara Holst	0f400ff5
Create requirements.txt	9 May 2024 19:46	Clara Holst	2b8245c8
Create vercel.json	9 May 2024 19:44	Clara Holst	c0f552b8
check	9 May 2024 19:40	Clara	e9ae0576
music	8 May 2024 23:43	Clara	7253f5b8
fixed quiz	8 May 2024 23:37	Clara	a51182b3
deck saving works	8 May 2024 23:11	Clara	82519e62
reverting back to normal database settings	8 May 2024 22:42	Clara	68866176
trial with database and new cards failed	8 May 2024 22:41	Clara	03ca0c33
new html titles in web browser	8 May 2024 17:54	Clara	8254d133
Scroll up button	8 May 2024 17:51	Clara	666b4084
button overlay	7 May 2024 13:53	Clara	1c81f789
modified home page	7 May 2024 13:51	Clara	74844f59
home page done	6 May 2024 15:56	Clara	8c87d6c4
Merge branch 'main' of https://github.com/Azrae101/AppliedCogSci	6 May 2024 14:32	Clara	fb1ca137
home page	6 May 2024 14:31	Clara	7b13ef43
Update README.md	1 May 2024 17:29	Clara Holst	915f961f
Update README.md	1 May 2024 17:24	Clara Holst	d7925ea9
Update README.md	1 May 2024 17:24	Clara Holst	6c8d9827
Update README.md	1 May 2024 17:22	Clara Holst	6d8cdd5e
Update README.md	1 May 2024 17:21	Clara Holst	67915569
Update README.md	1 May 2024 17:05	Clara Holst	947ab8b7
Update README.md	1 May 2024 17:04	Clara Holst	5145cbd7

Create README.md	1 May 2024 17:03	Clara Holst	7b702259
hello	1 May 2024 15:13	Clara	e004b0f3
my decks and public library	1 May 2024 14:14	Clara	64a5d817
Split long questions	1 May 2024 11:18	Clara	74bded2f
Icon	1 May 2024 10:33	Clara	4b516fc4
search button	29 Apr 2024 13:56	Clara	2b4152fb
game menu done	28 Apr 2024 16:45	Clara	d6bd7dab
prettier game settings	28 Apr 2024 14:15	Clara	17226572
science behind	27 Apr 2024 19:31	Clara	237979e0
Instructions to the games	27 Apr 2024 17:46	Clara	02805235
moved streak	25 Apr 2024 17:06	Clara	13c5b04f
about us	25 Apr 2024 15:35	Clara	aa950281
trying to make some tetris changes	25 Apr 2024 11:29	Clara	90bd161c
style	24 Apr 2024 14:11	Clara	739a58d9
some tetris changes	23 Apr 2024 21:39	Clara	e0e45160
Font	23 Apr 2024 20:09	Clara	dd6c2c68
style changes	23 Apr 2024 18:35	Clara	efe34d77
underscore in the name	23 Apr 2024 18:26	Clara	4292b5d6
All the game settings	23 Apr 2024 18:22	Clara	49a94ce7
game-settings	23 Apr 2024 14:46	Clara	dcf7e2c7
game settings startup	23 Apr 2024 13:27	Clara	5d1d3f38
thumbnail pictures	23 Apr 2024 12:57	Clara	a5fc96ee
Choose deck	22 Apr 2024 22:19	Clara	eeff96e7
Streak done	22 Apr 2024 22:14	Clara	97dc250f
Profile Settings Complete	22 Apr 2024 18:45	Clara	d1efbdd9
Minigames pretty	22 Apr 2024 16:00	Clara	5ed05395
profile	22 Apr 2024 14:30	Clara	fde258ca
Minigames gifs	22 Apr 2024 14:01	Clara	41d29927
DefineDash Complete	22 Apr 2024 13:00	Clara	a31bff4a
picture of definedash	17 Apr 2024 16:06	Clara	975aaa70
DefineDash Game	17 Apr 2024 16:04	Clara	140bbece
Merge pull request #13 from Azrae101/Azrael	17 Apr 2024 14:19	Clara Holst	37a394ca
Azrael origin TetriCards user-input	16 Apr 2024 12:56	Clara	33b855b4
Shapes	16 Apr 2024 12:02	Clara	f2b54b15
no key input	16 Apr 2024 11:20	Clara	46e2acaa
Tetris	16 Apr 2024 11:18	Clara	74519274
TetriCards	16 Apr 2024 10:01	Clara	7e429e17
TermTime in minigames	15 Apr 2024 22:49	Clara	5e840736
TermTime	15 Apr 2024 22:46	Clara	3a45f6d5
TermTime game and gifs	15 Apr 2024 22:41	Clara	1bf08db2
Tetris	12 Apr 2024 13:32	Clara	0caa5a22
Tetris	12 Apr 2024 13:31	Clara	ffb1c655
Minigames page	11 Apr 2024 16:39	Clara	1839ee3c
Search bar	3 Apr 2024 15:03	Clara	e9e4359d
resign of home page	3 Apr 2024 14:38	Clara	5425ae58
user input by enter	2 Apr 2024 20:32	Clara	a66fa427
Removed unnecessary code	2 Apr 2024 20:29	Clara	fc12e639
CardChase done for now	2 Apr 2024 20:28	Clara	1ebede32


points 2 Apr 2024 20:14 Clara f3494108
Endless but starts with running through the questions chronologically 2 Apr 2024 19:17 Clara 42714d68
user input button pretty 2 Apr 2024 19:08 Clara 3ccfbf8f
Styling of cardchase 2 Apr 2024 14:44 Clara 91ec940c
CardChase basic functionality works 2 Apr 2024 14:25 Clara 866c9635
CardChase fallen object 2 Apr 2024 13:22 Clara b9e691ef
login system improvement 2 Apr 2024 13:04 Clara df443218
Beginning of "Cardchase" 20 Mar 2024 12:48 Clara c3b6d806
Merge branch 'Login-system' 19 Mar 2024 11:50 Clara 9fe99d8d
Login-system origin Logout function 19 Mar 2024 11:49 Clara c94beab0
logo 19 Mar 2024 11:26 Clara 9e197199
Startup of login system 19 Mar 2024 11:25 Clara f50e7adf
Flask with Flashcards view and Quiz 18 Mar 2024 20:42 Clara ddeab6ae
Clara Merge pull request #12 from Azrae101/pine 9 Mar 2024 21:31 azbudrewicz c3170049
changed "give up" to "reveal the answer" 9 Mar 2024 21:30 azbudrewicz 1f22ae34
Merge pull request #11 from Azrae101/pine 8 Mar 2024 22:39 azbudrewicz 174aff84
previous/next button disabled when it's the first/last flashcard 8 Mar 2024 22:35 azbudrewicz c6f3591b
Merge pull request #10 from Azrae101/pine 8 Mar 2024 21:53 azbudrewicz bd88961d
previous/next button disabled when it's the first/last flashcard 8 Mar 2024 22:35 azbudrewicz c6f3591b
Merge pull request #10 from Azrae101/pine 8 Mar 2024 21:53 azbudrewicz bd88961d
functional hint button 8 Mar 2024 21:52 azbudrewicz dafe9478
Merge branch 'main' into pine 6 Mar 2024 13:31 azbudrewicz 12a95edf
Merge branch 'pine' 6 Mar 2024 13:30 azbudrewicz 813fb223
Merge pull request #8 from Azrae101/Tetris 6 Mar 2024 13:26 Clara Holst 2a737675
Tetris origin Endless and Normal mode 6 Mar 2024 10:18 Clara a2fd88c7
Randomize works!!! 6 Mar 2024 09:43 Clara 9cf5a738



Endless mode	6 Mar 2024 09:37	Clara	846516d7
Point counter	6 Mar 2024 09:21	Clara	9bc073e0
Checkpoint	5 Mar 2024 19:08	Clara	60c6b0ae
Randomize	5 Mar 2024 18:38	Clara	fb9e55c3
Collision works!	5 Mar 2024 16:37	Clara	f7312f52
functional buttons	5 Mar 2024 14:03	azbudrewicz	d248e858
Random spawn	5 Mar 2024 10:56	Clara	836f9efb
Merge pull request #7 from Azrae101/Tetris	5 Mar 2024 10:49	Clara Holst	206ef366
Merge branch 'main' into Tetris	5 Mar 2024 10:48	Clara	9c46a064
New boxes	5 Mar 2024 10:46	Clara	536871d9
Spawn new boxes	5 Mar 2024 10:46	Clara	ee351dba
title change	5 Mar 2024 10:13	azbudrewicz	4833e28d
Merge pull request #6 from Azrae101/Clara	5 Mar 2024 10:10	Clara Holst	5525d93c
origin/Clara Time each round	5 Mar 2024 10:08	Clara	2df12305
Collision between new elements	4 Mar 2024 22:01	Clara	3b11c8a4
More list elements	4 Mar 2024 21:10	Clara	b6e83a4c
changed the filename	2 Mar 2024 15:40	azbudrewicz	b4fa64dc
Merge pull request #5 from Azrae101/pine	2 Mar 2024 15:38	azbudrewicz	e07b8827
moved the "giveup" button	2 Mar 2024 15:34	azbudrewicz	a87ecd64
Merge pull request #4 from Azrae101/pine	2 Mar 2024 13:11	azbudrewicz	d1b5366e
added "giveup" button	2 Mar 2024 13:07	azbudrewicz	4708e441
You Won	28 Feb 2024 14:56	Clara	1006a71c
Beginning of Flask	28 Feb 2024 14:08	Clara	c899883c
Every list element works	28 Feb 2024 13:18	Clara	97eefcf1
Game Over	28 Feb 2024 12:10	Clara	10d573a6
Minigame: Before the definitions fall	28 Feb 2024 11:08	Clara	1bf8a6fc
One box at a time finished	28 Feb 2024 11:03	Clara	c5f6163d
Box collision with bottom	28 Feb 2024 10:04	Clara	b0dd3c01
Falling boxes	28 Feb 2024 09:31	Clara	9d4bbeb7
Quiz is completed	28 Feb 2024 09:21	Clara	81421a33
Tkinter display with user_input	27 Feb 2024 18:02	Clara	e1ab8d52
Terminal game	27 Feb 2024 17:35	Clara	e9340ce0
Start of project	27 Feb 2024 17:22	Clara	5928d951
Merge branch 'Merge'	27 Feb 2024 17:20	Clara	31491f4a
Merge *origin* test	27 Feb 2024 17:19	Clara	576f0737
Merge branch 'main' into Merge	27 Feb 2024 17:19	Clara	8042fb50
Merge branch 'Merge'	27 Feb 2024 17:19	Clara	145fd29e
Merge branch 'Merge' of https://github.com/Azrae101/AppliedCogSci	27 Feb 2024 17:18	Clara	ba151761
Merge branch 'main' into Merge	27 Feb 2024 17:18	Clara	cd0795fe



Game Over	28 Feb 2024 12:10	Clara	10d573a6
Minigame: Before the definitions fall	28 Feb 2024 11:08	Clara	1bf8a6fc
One box at a time finished	28 Feb 2024 11:03	Clara	c5f6163d
Box collision with bottom	28 Feb 2024 10:04	Clara	b0dd3c01
Falling boxes	28 Feb 2024 09:31	Clara	9d4bbeb7
Quiz is completed	28 Feb 2024 09:21	Clara	81421a33
Tkinter display with user_input	27 Feb 2024 18:02	Clara	e1ab8d52
Terminal game	27 Feb 2024 17:35	Clara	e9340ce0
Start of project	27 Feb 2024 17:22	Clara	5928d951
Merge branch 'Merge'	27 Feb 2024 17:20	Clara	31491f4a
Merge origin test	27 Feb 2024 17:19	Clara	576f0737
Merge branch 'main' into Merge	27 Feb 2024 17:19	Clara	8042fb50
Merge branch 'Merge'	27 Feb 2024 17:19	Clara	145fd29e
Merge branch 'Merge' of https://github.com/Azrae101/AppliedCogSci	27 Feb 2024 17:18	Clara	ba151761
Merge branch 'main' into Merge	27 Feb 2024 17:18	Clara	cd0795fe
test	27 Feb 2024 17:18	Clara	d0f8d8f6
Merge branch 'Merge'	27 Feb 2024 17:17	Clara	db64c247
Merge pull request #3 from Azrae101/main	27 Feb 2024 17:09	Clara Holst	e672641c
test	27 Feb 2024 17:02	Clara	a4b2e6a7
Test	27 Feb 2024 16:54	Clara	ff56a4eb
Merge pull request #2 from Azrae101/Merge	27 Feb 2024 16:52	Clara Holst	e0b0ca62
Merge conflicts display	27 Feb 2024 16:48	Clara	76ecfa26
Merge branch 'Clara'	27 Feb 2024 16:44	Clara	11274379
Merge conflicts	27 Feb 2024 16:44	Clara	8a03fff7
Merge branch 'main' of https://github.com/Azrae101/AppliedCogSci	27 Feb 2024 16:40	Clara	bccac74e
test	27 Feb 2024 16:40	Clara	96996cbd
Merge pull request #1 from Azrae101/Clara	27 Feb 2024 16:32	Clara Holst	b3bea2f2
Clara Branch	27 Feb 2024 16:32	Clara	82f2e616
lol	27 Feb 2024 12:41	Clara	af402f89
First commit	27 Feb 2024 09:35	Clara Holst	5638c585

Image 32-40:
The GitHub Gitgraph Progress Summary showcases the timeline of contributions to a project repository. The commits are organised by date, with each entry detailing the changes made, the contributor, and the timestamp of the commit.

Earlier in May, there were various updates, including fixes, additions to music and game settings, database updates, and changes to the home page.

The timeline extends back to March and February, showing a history of commits, including the initial project start, development of different game features, merges, and updates to the README file.

Overall, the picture of the GitGraph provides a chronological overview of the project's development, highlighting key contributions and changes made by the contributors over time.

Thank you for reading the assignment!