

# **An investigation into the hybridisation of board games: A scoping literature review**

Investigation into hybrid board games

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Advancement in digital technologies has given rise to a new trend within the field of board games known as hybrid board games – games which are played using physical components and digital elements. We conducted a scoping review investigating: (1) common technologies for incorporating digital elements into hybrid board games, (2) domains in which hybrid board games are most popular, (3) research methodologies best suited for studying the hybrid board games field and (4) most commonly used data collection methods. Our findings reveal a dynamic landscape ripe with opportunities for exploration and innovation. The emergence of hybrid board games has garnered attention beyond recreational contexts, in particular, in education and industry training. Smartphones and portable devices have facilitated seamless mobile integration of digital elements, opening new avenues for gameplay enhancement and new interaction styles. This synthesis sheds light on the multifaceted nature of research on hybrid board games, offering insights into its evolving trajectory and promising avenues for future inquiry.

CCS CONCEPTS • Human-centered computing ~ Collaborative and social computing • Applied computing ~ Computers in other domains

**Additional Keywords and Phrases:** Scoping review, Board games, Hybrid board games, Board game technologies

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## 1 INTRODUCTION

Board games are a form of tabletop games that require players to move pieces or tokens around a board in accordance with a set of rules [61]. Such games have existed for thousands of years with some of the most ancient forms of board games (boards consisting of multiple rows of holes carved out of limestone) dating back as far as 7000 BC [31]. Board games have stood the test of time with their popularity having grown rapidly during the last decade. The value of the board games industry was estimated to be approximately 7.2 billion U.S. dollars in 2017 and was forecast to nearly double, reaching a value of 12 billion U.S. dollars by 2023 [54]. Factors which may be influencing this are the opportunity board games provide for face-to-face social interaction, the introduction of innovative and diverse game designs, and the presence of a board gaming community in social media. Traditionally, board games were physical, requiring a board or play space and a number of components. However, with the advancement of digital technologies this is no longer the case, since games can now be hybridised to have digital elements.

For decades technology enthusiasts have argued that all media will eventually be digitalised [57]. As technological advancements have impacted traditional forms of entertainment such as music, television and video gaming, these new technologies have also impacted the board game industry. This has resulted in a new format of board games where traditional physical components are combined with digital elements to enhance gameplay [50]. As a relatively new development, researchers and industry professionals are yet to settle on one definitive term for this new format. Some of the more commonly used terms to describe such games are *hybrid (digital) board games* [50], *hybrid tabletop games* [24], *augmented (reality) board games* [13], and *phygital games* [27]. In this paper we refer to them as *hybrid board games*. This term is widely recognised and encompasses the integration of physical components with digital elements in board games, without using terms that may be borrowed from other mediums, such as *augmented* which is often associated with augmented reality, and *tabletop* which is commonly linked to tabletop role playing games (RPGs).

### 1.1 Rationale

As technology continues to evolve, hybrid board games are becoming more widespread and diverse in nature, boasting a broad range of digital elements, from mobile apps which utilise smartphone cameras in conjunction with QR codes or augmented reality, to playing pieces with LED screens [33]. However, board games which incorporate electronic components are not entirely new, as they have been in production since at least 1910 [24]. An example of this can be seen in the game *Electra* [51] where a player is alerted by a lamp when they accurately pair an answer with its corresponding question. More recently, rapid technological advancements in areas such as smartphone technology, augmented reality and digital sensors are strongly impacting the board game industry. It is becoming so widespread that many mass-market board game publishers, who primarily re-release their games with minor modifications, are incorporating various forms of digitisation in their games. For example, *Monopoly Electronic Banking* [17] includes an electronic device that functions as a credit card reader, offering players an experience not dissimilar to the real-world transition towards a cashless society.

A review of hybrid digital board games, defined as “boardgames in which play is enacted through both physical components and a ‘smart’ digital element” [50, p. 2] showed that by 2020, more than two thirds of all existing hybrid board games were released after 2016. This data suggests that in recent years hybrid board games are gaining in popularity and given their increasing presence in the board game industry over the past decade, suggests they are on an upward trajectory of popularity.

## 1.2 Objectives

Given the complex and multifaceted nature of hybrid board games, which integrate physical and digital elements, we conducted a scoping review to systematically map and synthesise existing research, identify gaps in knowledge, and provide suggestions for future research [16]. This review aims to further our understanding of the technological, social, and design implications of hybrid board games and to inform researchers and industry professionals about current trends and opportunities in this emerging field. As proposed by Peters, et al. [42] research questions used to this guide scoping reviews were broader and more expansive in their inclusion criteria than in a systematic review, in order to provide a wider scope. The research questions selected to guide this scoping review can be grouped into four categories, as presented in Table 1.

Table 1: Scoping categories and corresponding research questions

Categories	List of Questions
General Characteristics	RQ1. How have hybrid board game studies been distributed over time? RQ2. What publication types do hybrid board game studies fall under? RQ3. How can research studies into hybrid board games be categorised based on their research focus?
Hybridisation of board games	RQ4. Which technologies have been identified by previous studies as hybrid elements of hybrid board games?
Real world application of hybrid board games	RQ5. In what context, in addition to recreation, are hybrid board games used?
Research methodologies applied to study the hybrid board games field	RQ6. What methodologies have been used to study hybrid board games? RQ7. What data collection instruments have been used when researching hybrid board games?

The *general characteristics* category establishes a foundational understanding of the landscape of hybrid board game studies. By examining metadata such as the year of publication (RQ1), publication type (RQ2), and research focus category (RQ3), the goal is to create a snapshot of the current state of research, based on information obtainable from database records and the abstract, without reading the full text. This information is crucial for identifying trends, gaps, and potential areas for future research in this field. For example, knowing how research has evolved over time can highlight shifts in the popularity of this domain, or the impact of technological advancements. Categorising studies based on their research focus provides a clearer picture of the thematic directions that researchers have pursued.

The *hybridisation of board games* category explores the innovative technologies that transform physical board games into hybrid experiences (RQ4). Identifying these technologies is valuable for both researchers and industry professionals, as it highlights the tools and methods used to add digital elements to board games. This category not only addresses the existing body of work but also guides future research and development in the field.

The *real world application of hybrid board games* category goes beyond the realm of entertainment to examine the various contexts in which hybrid board games are utilised (RQ5). Understanding these contexts is important because it highlights the versatility and impact of hybrid board games in diverse settings, such as education and industry training. Exploring contexts outside of recreation can showcase the broader societal benefits of hybrid board games and identify potential areas for expansion and innovation.

Finally, the category on *research methodologies applied to study the hybrid board games field* focuses on the methods and instruments used in hybrid board game research (RQ6 and RQ7). The examination of the methodologies and data collection instruments employed highlights trends, strengths and weaknesses of current research practices and suggest

improvements. This, in turn, supports the development of more robust and reliable studies, ultimately advancing approaches in hybrid board games research.

## 2 METHODS

A scoping review was undertaken to analyse and synthesise the nature of published studies on the topic of hybrid board games. The methodology used is based on the framework proposed by Arksey and O'Malley [3], which consists of five stages: (1) identifying the research question(s), (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and finally (5) collating, summarising, and reporting the results. This framework was later extended and expanded by Levac, et al. [26] who emphasised the importance of an iterative review processes to refine the research questions and data extraction criteria. The most recent version of this framework was enriched in 2015 by Joanna Briggs Institute (JBI) working group [42] which included rigorous data extraction techniques. Additionally, in 2018 the Preferred Reporting Items for Systematic Reviews (PRISMA) Statement was extended to include scoping reviews (PRISMA-ScR), and a checklist of guidelines was developed. The checklist which contains 20 essential reporting items and 2 optional items was closely followed to ensure this scoping review was conducted comprehensively and accurately [55].

### 2.1 Eligibility criteria

The following criteria were applied when selecting studies to be included in this scoping review:

1. The study discussed hybrid board games in a significant manner. The following examples do not qualify for inclusion:
  - a. Studies focusing on hybridity outside of the hybrid board game medium such as hybrid reality or hybrid learning;
  - b. Studies focusing on video games which do not have physical or tangible components;
  - c. Studies focusing on traditional board games without digital elements.
2. The language of the study is English;
3. Full text of the study is available;
4. The study has been published in a journal or a conference that uses blind refereeing;

Any study not meeting all four criteria were excluded. A publication date range was specifically avoided as part of the inclusion criteria as this would limit the ability to demonstrate the temporal development and history of the hybrid board game phenomenon [15].

### 2.2 Information sources

The sources of evidence incorporated into this literature review were identified through the retrieval of records from four databases: SCOPUS, Web of Science, IEEE, and AMC Digital Library. These databases were chosen as they typically index only reputable sources which have been peer reviewed and published in esteemed journals and conferences, This ensured that non-refereed sources referred to as *grey literature* were not included [55]. In addition to the primary database search results, several studies marked as *Secondary Documents*<sup>1</sup> by SCOPUS were included in the results as these studies fit the criteria listed above, although they were not indexed by SCOPUS.

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<sup>1</sup> "A secondary document is a document that has been extracted from a Scopus document reference list but is not available directly in the Scopus database since it is not indexed by Scopus" [12].

### 2.3 Search

In conducting a scoping review on the topic of board games that integrate physical and digital elements, it is crucial to use terminology that accurately captures the breadth and depth of the existing literature. *Hybrid board games* has emerged as a widely recognised and commonly used term within both academic and industry contexts to describe this integration. The prevalence of this term ensures that a significant proportion of relevant studies will be identified through its use.

Thus, the following search strings were entered into SCOPUS, Web of Science, IEEE and ACM Digital Library to retrieve records for this scoping literature review:

1. Hybrid AND board AND game
2. Hybrid AND boardgame

The ACM digital library database was restricted to searching only the titles and abstracts of database records as the initial search retrieved more than 5000 results with many of them being irrelevant. In contrast, other databases such as Scopus and Web of Science returned only around 100 results without this restriction.

The most recent searches were conducted on the 21st November 2023.

### 2.4 Selection of sources of evidence

The initial selection of studies was conducted by one of the researchers within the team. The screening process included evaluating the titles, abstracts and in some cases full texts of studies (where a deeper understanding of the research was required) to determine their eligibility. Each excluded source of evidence was justified using the inclusion criteria and documented in a spreadsheet.

### 2.5 Data charting process and data items

As per guidelines from JBI Manual for Evidence Synthesis [43], a custom data charting form was developed and populated with data items addressing the research questions.

The data items range in generality and specificity, with each one corresponding to one of the four categories from Table 1. This is shown in Table 2 which identifies the scoping categories and their corresponding data items. Each data item was selected to directly address a corresponding research question.

Table 2: Scoping categories and corresponding data items

Categories	Data Items
General Characteristics	<ul style="list-style-type: none"><li>• Publication year (RQ1)</li><li>• Publication type (RQ2)</li><li>• Research Focus Category (RQ3)</li></ul>
Hybridisation of board games	<ul style="list-style-type: none"><li>• Digital technologies used in hybrid board game development (RQ4)</li></ul>
Real world application of hybrid board games	<ul style="list-style-type: none"><li>• Context of hybrid board game use (in addition to recreation) (RQ5)</li></ul>
Research methodologies applied to study the hybrid board games field	<ul style="list-style-type: none"><li>• Methodologies (RQ6)</li><li>• Data collection instruments (RQ7)</li></ul>

### 2.6 Synthesis of results

The results of the scoping review are presented in two formats. Firstly, the completed data charting form is presented. This data charting form documents all manuscripts included in this review, along with each of their data items. The data charting form is sorted alphabetically based on the first author's name. Secondly, each research question used to help guide this

review is answered in a narrative format, with some questions having visual assets such as charts and graphs to help illustrate the results.

### 3 RESULTS

#### 3.1 Selection of sources of evidence

The database searches yielded a total of 281 search results with 132 records retrieved from SCOPUS (including *Secondary Documents*), 112 retrieved from Web of Science, 37 retrieved from IEEE and 21 from ACM Digital Library. A total of 125 duplicates were removed. The remaining 156 records were evaluated against the inclusion criteria. As a result, 116 records were excluded due to the following:

- 111 studies did not discuss hybrid board games in a significant manner focusing instead on:
  - a) hybridity outside of the hybrid board game medium such as hybrid reality or hybrid learning;
  - b) video games which do not have physical or tangible components;
  - c) studies focusing on traditional board games without digital elements.
- three studies did not have full-text available;
- and two studies were rejected due to one of them being a blog post and another a Masters level thesis.

Ultimately this resulted in 40 studies qualifying for inclusion in this scoping review, having met all of the inclusion criteria. The PRISMA 2020 flow diagram (Figure 1) documents the identification, screening and inclusion process.

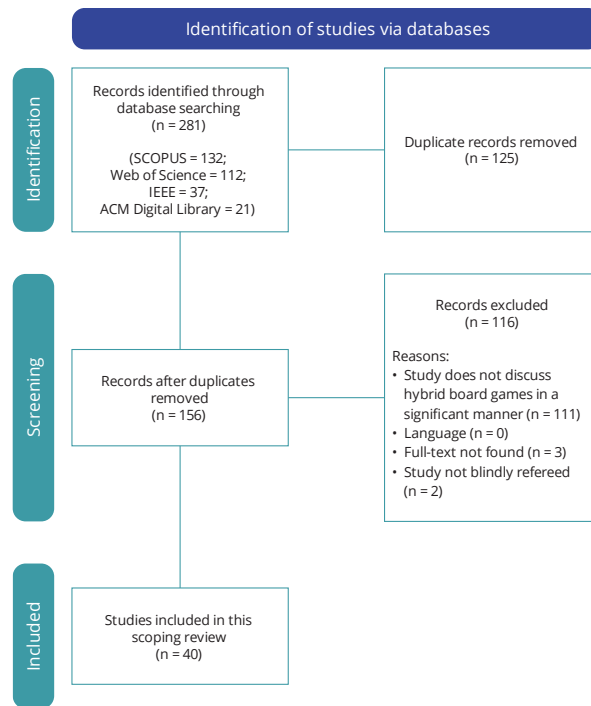


Figure 1: PRISMA flow diagram of identification, screening and inclusion process. Adapted from [40].

Thoroughly following this process resulted in data as depicted in Table 3.

Table 3: Completed data charting form

Authors	Year	Publication type	Research focus category	Digital technologies used in hybrid board game development	Context of hybrid board game use (in addition to recreation)	Methodologies	Data collection instrument
Ali, et al. [1]	2023	Conference Paper	Hybrid board games in education and training	Web app	Education (Secondary)	Mixed Methods	Knowledge test; Survey; Interviews
Arjoranta, et al. [2]	2016	Conference Paper	Theoretical / conceptual paper			Not specified	No data collection
Booth [4]	2016	Journal Article	Theoretical / conceptual paper			Not specified	Analysis of existing artefacts
Cavicchini and Mariani [5]	2019	Conference Paper	Theoretical / conceptual paper			Not specified	No data collection
da Silva Júnior, et al. [7]	2021	Journal Article	Hybrid board games in education and training	Mobile app	Education (Tertiary - Undergraduate)	Mixed Methods	Survey
da Silva Júnior, et al. [8]	2020	Journal Article	Hybrid board games in education and training	Mobile app	Education (Tertiary - Undergraduate)	Mixed Methods	Knowledge test; Survey
da Silva Júnior, et al. [9]	2020	Journal Article	Hybrid board games in education and training	Mobile app	Education (Tertiary - Undergraduate)	Mixed Methods	Survey
da Silva Júnior, et al. [10]	2020	Journal Article	Hybrid board games in education and training	Mobile app	Education (Tertiary - Undergraduate)	Mixed Methods	Knowledge test; Survey
Den Haan, et al. [11]	2020	Journal Article	Hybrid board games in education and training	Webcam, touchscreen monitor, projector, software built in Python	Industry Training	Mixed Methods	Knowledge test; Survey; Gameplay testing session
Golombek, et al. [13]	2016	Conference Paper	Game creation	Augmented reality		Not specified	No data collection
Gómez-Maureira, et al. [14]	2020	Conference Paper	Taxonomy			Not specified	No data collection
Jadán-Guerrero, et al. [18]	2020	Conference Paper	Hybrid board games in education and training	Augmented reality, NFC tags, QR codes	Education (Primary & Special Needs)	Qualitative	Workshops

Authors	Year	Publication type	Research focus category	Digital technologies used in hybrid board game development	Context of hybrid board game use (in addition to recreation)	Methodologies	Data collection instrument
Jean-Daubias [19]	2023	Journal Article	Hybridisation of physical board games	QR codes	Education (Tertiary - Undergraduate); Industry Training	Mixed Methods	Survey
Jensen, et al. [20]	2020	Conference Paper	Hybridisation of physical board games	Electrochromic inks		Qualitative	Gameplay testing session; Interviews
Kafai and Vasudevan [21]	2015	Conference Paper	Hybrid board games in education and training	Digital dice, digital playing cards coded in Scratch	Education (Middle School)	Qualitative	Workshops
Kankainen [22]	2016	Conference Paper	Comparing physical and digital versions of same game			Qualitative	Interviews
Kankainen and Paavilainen [23]	2019	Conference Paper	Design guidelines			Qualitative	Workshops; Interviews; Analysis of existing artefacts; Survey
Mandryk and Maranan [28]	2002	Conference Paper	Game creation	Sensor interface, handheld computers, software		Not specified	No data collection
Marco, et al. [29]	2016	Journal Article	Game creation	Platform for developing hybrid board games (visual sensors or sensors built)		Mixed Methods	Workshops; Survey
Martins, et al. [30]	2022	Conference Paper	Hybrid board games in education and training		Education (Primary)	Qualitative	Interviews
Maurer and Fuchsberger [32]	2019	Journal Article	Design guidelines			Not specified	No data collection
Mora, et al. [33]	2016	Journal Article	Hybridisation of physical board games	Interactive tokens (with LED displays)		Mixed Methods	Gameplay testing session; Survey
Mora, et al. [34]	2016	Conference Paper	Game creation	Platform for developing hybrid board games (sensors built into pieces)		Not specified	No data collection
Nummenmaa and Kankainen [36]	2019	Conference Paper	Attitudes			Qualitative	Analysis of existing artefacts



Authors	Year	Publication type	Research focus category	Digital technologies used in hybrid board game development	Context of hybrid board game use (in addition to recreation)	Methodologies	Data collection instrument
O'Brien [37]	2017	Conference Paper	Game creation	Mobile app		Not specified	No data collection
Oliveira, et al. [38]	2020	Conference Paper	Hybrid board games in education and training		Education (Primary)	Not specified	No data collection
Onencan [39]	2018	Conference Paper	Theoretical / conceptual paper			Mixed Methods	Gameplay testing session; Survey
Park [41]	2017	Journal Article	Game creation	Mobile app, electronic physical playing board (rechargeable battery, solar charger, LCD panel), RFID tags		Mixed Methods	Gameplay testing session; Survey
Polyak, et al. [44]	2017	Conference Paper	Hybrid board games in education and training	Mobile app	Education (Primary)	Not specified	No data collection
Rangarajan, et al. [45]	2023	Conference Paper	Game creation	Augmented reality	Education	Mixed Methods	Survey
Reisinho, et al. [46]	2021	Conference Paper	Hybrid board games in education and training	Mobile app, augmented reality, RFID tags	Education (Primary)	Qualitative	Gameplay testing session; Survey
Reisinho, et al. [47]	2021	Conference Paper	Hybrid board games in education and training	Mobile app, augmented reality, RFID tags	Education (Primary)	Not specified	No data collection
Rogerson, et al. [48]	2021	Conference Paper	Taxonomy			Mixed Methods	Gameplay testing session; Survey; Interviews
Rogerson, et al. [50]	2021	Conference Paper	Design guidelines			Qualitative	Interviews
Rogerson, et al. [49]	2022	Conference Paper	Game creation			Mixed Methods	Workshops, Survey
Sparrow and Rogerson [52]	2023	Journal Article	Design guidelines			Qualitative	Survey
Tu, et al. [56]	2023	Conference Paper	Hybridisation of physical board games	RFID tags		Qualitative	Gameplay testing session, Interview

Authors	Year	Publication type	Research focus category	Digital technologies used in hybrid board game development	Context of hybrid board game use (in addition to recreation)	Methodologies	Data collection instrument
Vayanou, et al. [58]	2019	Journal Article	Game creation	Platform for developing hybrid board games (visual sensors or sensors built into pieces)		Qualitative	Gameplay testing session; Survey; Focus groups
Wang, et al. [60]	2019	Conference Paper	Hybrid board games in education and training	Augmented reality	Education (Secondary - Junior High)	Quantitative	Survey
Xu and Buruk [62]	2022	Conference Paper	Hybridisation of physical board games	Web platform		Mixed Methods	Gameplay testing session; Survey; Interviews

### 3.2 Synthesis of results

This section presents the results of the scoping review with respect to each of the research questions posed in Table 1, aligned with the four categories of general characteristics, hybridisation of board games, real world application of hybrid board games and research methodologies in studies related to hybrid board games.

#### 3.2.1 General characteristics

Research questions included in the *general characteristics* category examine the metadata associated with the selected sources of evidence. This includes the year of publication, publication type and research focus category. The purpose of this category is to generate a snapshot of the studies conducted in the field of hybrid board games and to identify trends based on information obtainable from database records and the abstract without reading the full text.

*RQ1. How have hybrid board game studies been distributed over time?*

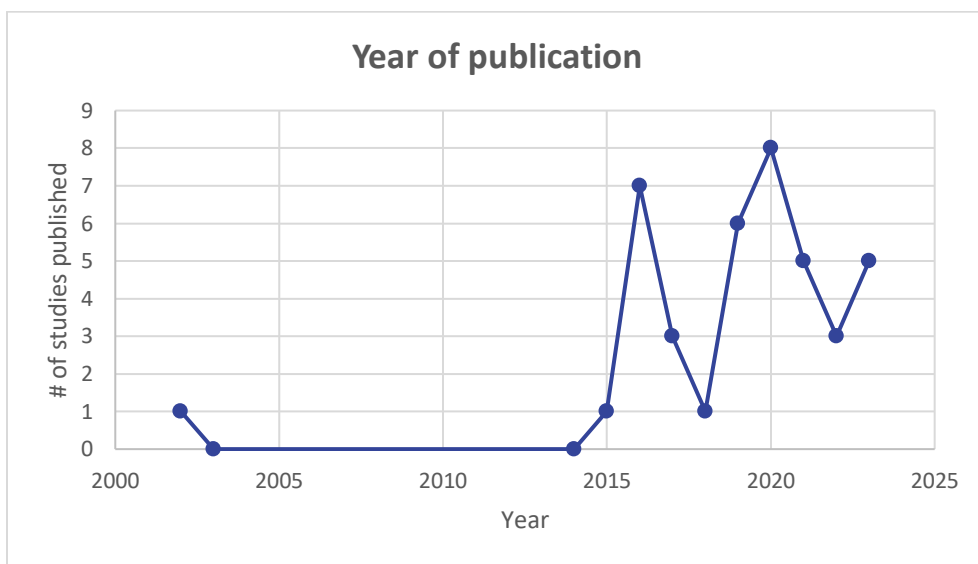


Figure 2: Year of publication

Figure 2 identifies the years during which research studies focusing on the field of hybrid board games were published. Mandryk and Maranan [28] published the first study on hybrid board games exploring this new subgenre of board games by creating a hybrid board game. The game’s hybridisation was achieved by implementing a display system utilising a sensor interface on a tabletop.

From 2002 until 2015 there was a dearth of research conducted into hybrid board games, evidenced by lack of studies during this period. However, as hybrid board games started to gain more and more popularity and games were being released at a rapid rate, researchers once again returned to exploring this phenomenon. The year 2016 saw a spike in the amount of research conducted in this field. This could potentially be attributed to the increase in the popularity of hybrid board games and the corresponding increase in hybrid board game releases, since the number of hybrid board games commercially released almost doubled within the year 2016 alone [50].

Since 2016, the number of studies per year fluctuated with some years seeing as few as one study published per year, while other years saw upwards of five studies. The year 2020 saw the largest contribution to date with eight published studies, which is still quite low compared to other related disciplines, such as video games.

There is an interesting correlation between hybrid board game releases and research studying hybrid board games. As of 2020 more than two thirds of all existing hybrid board games were published after 2016 [50] – the same is true for studies researching this phenomenon.

In summary, judging from the results, hybrid board game research began in 2002, experienced a hiatus until 2015, and a resurgence in 2016 aligning with increased game popularity. The annual trend of published studies fluctuated, peaking in 2020. Notably, over two-thirds of games and studies emerged after 2016, correlating with recent and impactful developments in this field.

*RQ2. What publication types do hybrid board game studies fall under?*

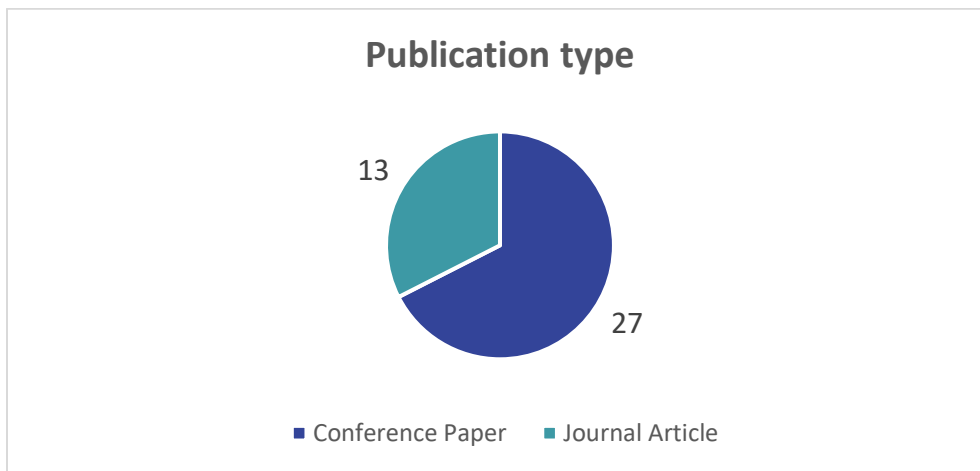


Figure 3: Publication type

A publication type is defined by the venue through which research findings were disseminated. In this scoping review only two types were accepted – journals and conferences that follow a formal blind refereeing process. Figure 3 shows the breakdown by publication venues for studies included in this scoping review. Of the 40 studies which have been included, just over two-thirds (27 publications) are conference papers, while the remaining one-third (13 publications) are journal articles.

In summary, the distribution of publication types of studies included in the scoping review reveals that the majority of the included studies are conference papers, with corrections made for occasional misidentifications by the databases, ensuring accurate representation of the publication types.

RQ3. How can research studies into hybrid board games be categorised based on their research focus?

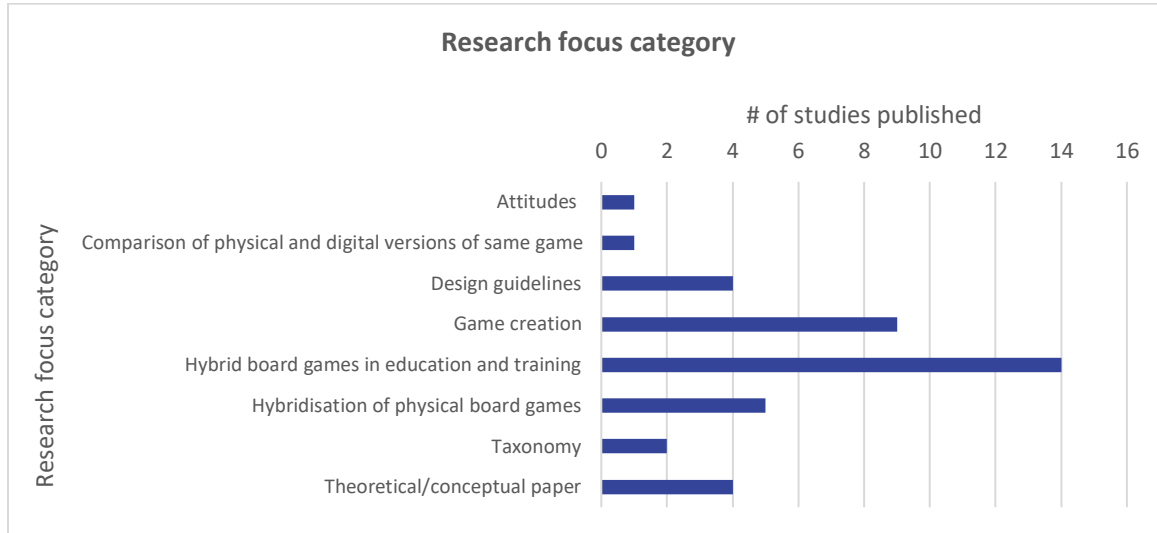


Figure 4: Research focus category

As depicted in Figure 4, the 40 studies included in this scoping review can be categorised into eight groups based on their research focus. To achieve this, the affinity mapping process was used by first writing out the research focus of each study on a separate post-it note, then clustering similar research foci together into groups, and finally naming and describing the clusters [25]. Table 4 identifies and describes these categories.

Table 4: Research focus category and description

Research focus categories	Descriptions
Attitudes	Industry professionals' or consumers' feelings towards hybrid board games
Comparison of physical and digital versions of the same game	A direct comparison between a physical board game and its digital adaptation (not a hybrid board game)
Design guidelines	A set of guidelines formulated to guide hybrid board game designers for best practice in hybrid board game design
Game creation	The focus of the research was to create a hybrid board game or support the creators of hybrid board games by providing game development tools
Hybrid board games in education and training	The use of hybrid board games for the primary purpose of education or training, as opposed to recreation
Hybridisation of physical board games	The focus of the study was to hybridise an analogue board game by incorporating a digital element
Taxonomy	The output of the research manifested itself in the form of a taxonomy to categorise various aspects related to hybrid board games
Theoretical/conceptual papers	Studies which attempt to interpret or explain the phenomenon based on past research studies

Initially the studies were allocated to broad clusters based on their research focus (Table 4). However, some studies within the same category were sufficiently different, therefore they were allocated to different subcategories. For example,

Nummenmaa and Kankainen [36] explored attitudes towards hybrid board games, however their data collection focused specifically on the evaluation of marketing materials. Another example of subcategorization could be applied to the *game creation* category. Although seven studies focused on the design and development of a hybrid board game, Marco, et al. [29], Mora, et al. [34], Rogerson, et al. [48] and Vayanou, et al. [58] all pivoted towards the creation of tools or platforms to assist others with the development of hybrid board games. Therefore, these three manuscripts were allocated to the subcategory *Tools and platforms for rapid game development*.

The *hybrid board games in education and training* category were broken down into two sub-categories, one based on the use of hybrid board games in education (12 papers) and a category dedicated to industry training (one paper written by Den Haan, et al. [11]). The subcategory on hybrid board games in education were subdivided even further, with the distinguishing factor being education level – school or tertiary. Six studies focused on primary school children, of which Jadán-Guerrero, et al. [18] also designed for children with special needs. Kafai and Vasudevan [21] focused on middle school children, while Ali, et al. [1] targeted their game towards secondary school students, and Wang, et al. [60] researched the impact of their game on junior high students. Only four studies were dedicated to hybrid board games used in tertiary education, which are da Silva Júnior, et al. [7], da Silva Júnior, et al. [8], da Silva Júnior, et al. [9], da Silva Júnior, et al. [10].

In summary, the categorisation of the studies included in this scoping review, reveals the diverse research foci within the field of hybrid board games. The initial broad clustering was refined to incorporate subcategories, highlighting the nuanced differences among studies with a similar research focus.

### 3.2.2 Hybridisation of board games

The *hybridisation of board games* category examines the ways in which board game developers can utilise innovative digital technologies to integrate digital elements in their games. This is not limited to existing board games that are later hybridised but instead looks the game design process and the available technologies used to implement digital features into otherwise physical games.

#### *RQ4. Which technologies have been identified by previous studies as hybrid elements of hybrid board games?*

Mobile, and by extension, web apps were the most common technologies for incorporating digital elements into hybrid board games. Although the approaches for mobile app integration were quite diverse, some of the more common examples were:

- The use of randomisation functionality to
  - shuffle a virtual deck of cards [21, 37];
  - roll virtual dice [9, 10, 21];
  - randomise a list of questions [7, 9, 10];
- Displaying questions to players
  - in a specific sequence based on an inputted 3-digit code [8];
  - based on the *level* inputted [44];
- Allowing players to input data into the app to use as a resource or virtual currency [62];
- Storing gameplay related information for users to refer back to such as quest objectives, items in a player's inventory and active effects [37].

Another popular use of mobile apps was to harness the power of augmented reality as implemented through smart phone technology. Jadán-Guerrero, et al. [18], Rangarajan, et al. [45] and Wang, et al. [60] used software development kits for augmented reality applications built in Unity such as AR Foundation and Vuforia.

A common alternative to using a mobile or web app was to digitise the game pieces or the game board itself. This approach utilises a combination of software with commonly available hardware. An example of this is the hybrid game developed by Den Haan, et al. [11], which integrated an off the shelf webcam, touch screen monitor and projector with a custom-built software to control the digital aspects of the game. Mora, et al. [33] used interactive game pieces which had LED displays to dynamically display information to the player and sensors to feel the players' tangible interactions. Another example of this is the use of RFID tags which were used by Park [41], Reisinho, et al. [46], Reisinho, et al. [47] and Tu, et al. [56].

Jensen, et al. [20] created their own resource tiles for the board game *Settlers of Catan* [53] by harnessing the power of electrochromic inks. These digitally controlled tiles functioned as standard resource tiles that were able to dynamically change the resource at randomised intervals.

An important consideration when utilising digital elements is their reliance on a source of power. Board games are designed to be portable and therefore are not developed with power supplies in mind. Although batteries are the most common form of portable power, Park [41] explored the use of a solar powered charger which was connected to a rechargeable Lithium-ion battery.

To aid prospective hybrid board game developers, Marco, et al. [29], Mora, et al. [34] and Vayanou, et al. [58] focused their research on developing platforms that would assist with the technological aspects of hybrid board game development. Marco, et al. [29] created *ToyVision*, a software framework based on the *reactIVision* toolkit for tangible multi-touch interfaces. *ToyVision* can be used to prototype board games based on the physical manipulation of standard playing pieces with the use of technologies such as a digital camera to act as a visual sensor, or sensors built into custom playing pieces. Mora, et al. [34] developed *Anyboard*, a platform designed to allow game designers to build prototypes of hybrid board games without prior skills in engineering. This has been done using augmented game pieces with built-in processors and Bluetooth Low Energy radio transmitters and a card holder which uniquely prints cards on demand as opposed to storing them. These augmented devices are controlled by software coded using *AnyboardJS*, a JavaScript library. Vayanou, et al. [58] created their own hybrid board game experience which uses physical cards depicting various artworks and digital narratives which are presented to the players on handheld devices. In addition to developing the game for their own project, Vayanou, et al. [58] expanded upon this by modifying the software used into a game-authoring platform and mobile application. The game authoring platform, coded in Java, JavaScript, HTML and CSS, is a digital repository which enables designers to input their own data in order to create custom experiences unique to them.

In summary, when examining technologies researchers have utilised for hybridising board games, mobile and web apps are prevalent in integrating digital elements into hybrid board games, offering diverse functionalities. Alternatives include augmented reality, digitisation of game pieces, and innovative technologies like RFID tags and electrochromic inks. Researchers have also been contributing to the creation of hybrid board games by designing platforms to assist game developers. This diversity in technological tools highlights the multitude of options that hybrid board game developers have available to incorporate digital elements into board games.

### 3.2.3 Real world application of hybrid board games

Exploring beyond the realm of entertainment, the *real world application of hybrid board games* category delves into the diverse contexts in which hybrid board games find practical use. Investigating contexts beyond recreation can demonstrate the broader benefits of hybrid board games and uncover potential areas for growth and innovation.

*RQ5. In what context, in addition to recreation, are hybrid board games used?*

As illustrated in Figure 4, the most common research focus of studies in the field of hybrid board games was on the application of such games in education and training. No other application domains for games were found in past research studies. Some authors referred to the games they created as *serious games*, but in this research we did not separate *serious games* into their own category as the *serious* aspect of the game focuses on their purpose to educate, rather than just provide a form of recreation. Thus, they fall under the umbrella of educational games.

Den Haan, et al. [11] published the only study on how hybrid board games were used exclusively for industry training purposes. Their research focused on the creation of a hybrid board game which was designed to provide a collaborative environment for stakeholders involved in river management in the Netherlands.

Six studies focused on hybrid board games for primary school children, however Jadán-Guerrero, et al. [18] also extended their target demographic to include special needs children. Martins, et al. [30], Oliveira, et al. [38], Reisinho, et al. [46] and Reisinho, et al. [47] are a series of four studies reporting on the research project *FlavourGame*. These works document the theoretical discussion, creative process, character design and the possibilities of incorporating tangible interfaces and augmented reality in a hybrid board game for primary school children on the topic of nutrition.

Kafai and Vasudevan [21] explored approaches to constructionist gaming by having middle school students create their own games in the Scratch programming environment. The focus was on experimentation with forms of hybridity namely through wearable controllers, touchpads and hybrid board games to create rich multi-sensory experiences, as well as facilitate learning of programming and develop computational thinking. This research approach was unique compared to other research conducted into hybrid board games in education as in this case, it was not the researchers developing a game for students, but rather the students being the ones creating the game.

Studies by da Silva Júnior, et al. [7], da Silva Júnior, et al. [8], da Silva Júnior, et al. [9], da Silva Júnior, et al. [10] all focused on creating hybrid board games as educational tools for second-year undergraduate students to learn concepts in organic chemistry. These studies covered not only the creation of hybrid board games but also evaluation of the games based on metrics such as acceptance attitudes and contribution to learning.

Jean-Daubias [19] created a board game to teach software ergonomics to undergraduate students, however their game was also used for intensive training of professional computer engineers.

In summary, the primary research focus in the field of hybrid board games is their application in education and training, particularly for primary school children and those with special needs. Notable studies involve unique approaches, such as middle school students creating their own hybrid board games and the development and evaluation of educational games for undergraduate students learning organic chemistry. These contributions highlight the versatility and practicality of hybrid board games in diverse educational contexts.



### 3.2.4 Research methodologies applied to study the hybrid board games field

In the category centred on *research methodologies applied to study the hybrid board games field* the focus lies on the varied research approaches employed in examining the hybrid board games domain. This investigation examines the diverse methodologies adopted and the range of data collection instruments utilised by researchers in their study of hybrid board games.

RQ6. *What methodologies have been used to study hybrid board games?*

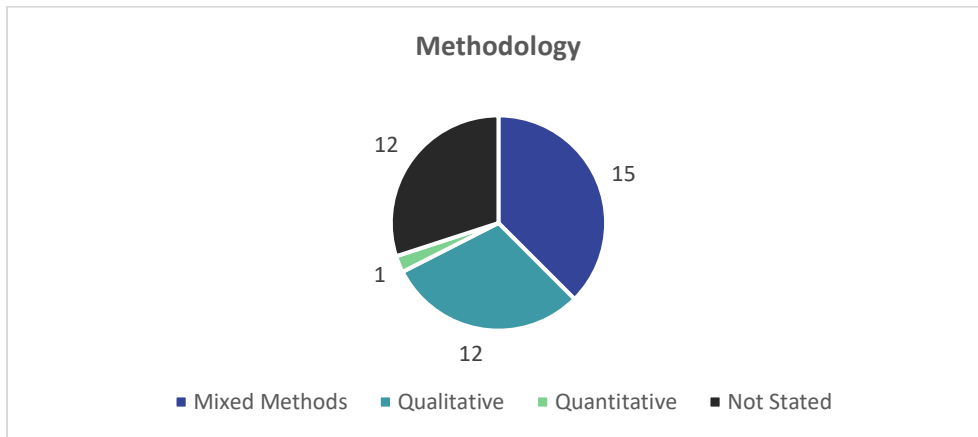


Figure 5: Methodology

Figure 5 depicts the methodologies used by researchers when studying hybrid board games. Just under one third of included studies did not specify a clear research methodology when reporting their research. The majority of these studies fell into the research focus categories of *theoretical/conceptual paper*, *taxonomy*, *design guidelines* and *game creation* – which typically do not rely on data collection and data analysis conforming to a specific methodology. Of the studies that did report their chosen methodology, just under half opted for a qualitative approach the remaining majority adopting a mixed methods approach. Wang, et al. [60] were the only researchers to use a quantitative research methodology. In their study they documented using a survey with a Likert-type scale and analysed this data using a statistical t-test.

The majority of analysed studies utilised either a qualitative or mixed methods research methodology. Only five studies explicitly stated that they were using a qualitative research methodology. However, it was possible to infer from data collection and analysis that seven other studies also used a qualitative approach. Several qualitative studies clearly described how they applied open coding and thematic content analysis, therefore demonstrating how they arrived at the findings. The manuscripts illustrating this research process in depth are studies by Kafai and Vasudevan [21], Kankainen [22], Nummenmaa and Kankainen [36] and Sparrow and Rogerson [52].

In summary, an analysis of the studies included in the scoping review provides a comprehensive overview of the methodologies employed in the study of hybrid board games. A significant portion of studies did not specify a methodology as their research approach did not involve data collection and data analysis, while those explicitly stating their approach predominantly favoured qualitative or mixed methods. The value placed on gameplay experiences in this industry makes qualitative methods particularly conducive to capturing rich insights.

RQ7. What data collection instruments have been used when researching hybrid board games?

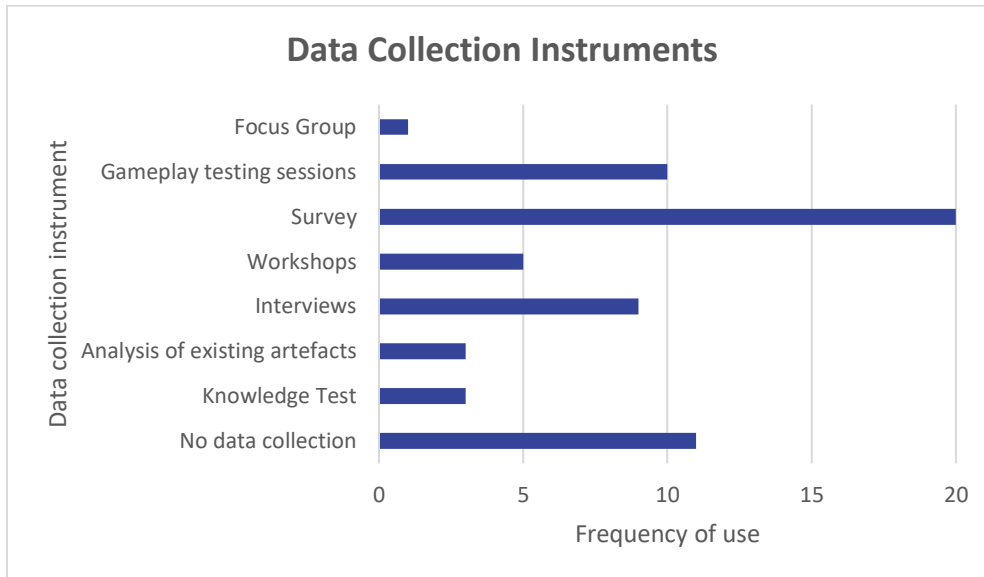


Figure 6: Data collection instruments

Figure 6 shows various data collection instruments used in the included manuscripts. There are manuscripts that used only one data collection method as part of their research, however many researchers used a combination of data collection instruments to triangulate their findings or to get additional insights. Eleven manuscripts did not use data collection methods, as their research had a theoretical/conceptual contribution that did not rely on data collection.

One of the most useful data collection methods when evaluating board games is gameplay testing sessions. These sessions are a combination of usability testing and focus groups, adapted to evaluate the board game medium. Taking the *group* aspect from focus groups, gameplay testing sessions see numerous participants play a board game or prototype. This reflects the real-world scenario of board game play since a vast majority of board games are designed to be played in groups. However, gameplay testing sessions can also exhibit aspects of usability testing, as participants critically evaluate the usability and user experience of the board game [50]. Gameplay testing sessions are hosted by a facilitator who guides the participants during the sessions which are often recorded or directly observed live by researchers. Den Haan, et al. [11] were able to use in-game analytics from within the digital element of their hybrid board game to obtain additional data from the gameplay testing session conducted as part of their research. Another common feature of the gameplay testing sessions was that participants would be questioned after a session, allowing for further insights into their experience [11, 39].

Surveys were also a popular form of data collection, however they were usually used in conjunction with other data collection instruments. Manuscripts by da Silva Júnior, et al. [8], da Silva Júnior, et al. [9], Jean-Daubias [19], Rangarajan, et al. [45], Sparrow and Rogerson [52], as well as the article by Wang, et al. [60] relied solely on surveys as a data collection method. However, in most cases these surveys were structured using the Likert-type scale in conjunction with open-ended questions allowing participants to provide detailed feedback on their experience.

A number of studies sourced existing artefacts as data for their research. Booth [4] and Kankainen and Paavilainen [23] examined existing hybrid board games to inform their study, while Nummenmaa and Kankainen [36] used marketing materials that advertised commercially produced hybrid board games as data for their research.

Focus groups were not frequently used as a data collection method for research into hybrid board games as focus groups usually involve small groups discussions guided by a facilitator [35]. As gameplay testing sessions also have the participants engage in the testing of a prototype, they are able to provide detailed real-time feedback on interactions within the gameplay that are more difficult to extract out of a focus group session.

Some studies, for example Ali, et al. [1], da Silva Júnior, et al. [7] and da Silva Júnior, et al. [10], all created hybrid board games as tools to improve student learning. Learning outcomes were evaluated by conducting quizzes, which also provided an evaluation of the effectiveness of their hybrid board games.

In summary, an examination of the sources of evidence included in this review shows the varied data collection instruments employed in hybrid board game studies. While some research utilised a singular approach, a significant number adopted a combination of data collection instruments for a richer set of data. Gameplay testing sessions emerged as a pivotal method, blending aspects of usability testing and focus group dynamics to simulate authentic board game experiences. Surveys were a common tool, often structured with Likert-type scales and open-ended questions. Some studies also derived insights from existing artifacts, such as existing hybrid board games or marketing materials. Educational game creators employed knowledge tests to assess the effectiveness of their games as educational tools. This encompasses the plethora of data collection methods available to researchers when studying hybrid board games.

## 4 DISCUSSION AND CONCLUSIONS

### 4.1 Discussion of evidence

This section summarises answers to the research questions posed by this study.

When it comes to studying the field of hybrid board games, researchers have a broad range of research foci available to them. Examining the diverse research directions taken by the authors of the 40 studies included in this scoping review, reveals research foci that could be grouped into 8 broad categories. The more popular categories include *hybrid board games in education and training*, *game creation* and *hybridisation of physical board games*. The initial broad categories were refined further to incorporate subcategories, further highlighting differences between studies with similar research foci. This was especially relevant for the most popular category, *hybrid board games in education and training*, as it could be broken down further into more refined subcategories separating education from industry training, as well as differentiating education levels. The less popular research focus categories such as *attitudes* and *comparison of physical and digital versions of the same game* offer opportunities for future research to be conducted in these relatively unexplored areas.

One of the more popular research foci in the field of hybrid board games is the way in which hybrid board games can be used in various contexts. Hybrid board games are primarily used as forms of recreation, however, as the findings of this review showed, several researchers were interested in exploring how hybrid board games can be used for other purposes, primarily for education at different age ranges. Gamification is a popular approach to enhancing the learning experience to help boost engagement, thus improving quality of the learning process as well as learning outcomes, especially amongst younger audiences such as school children [6]. Numerous studies have explored how hybrid board games can be used as a tool to support education. There is also diversity in how hybrid board games are applied in the educational environment.

For example, rather than the educators creating a hybrid board game as an educational tool, Kafai and Vasudevan [21] instead had students create their own hybrid board games.

The use of games as a tool for industry training is not new. A high-profile example known in the gaming community as well as within the fast-food industry is KFC's VR video game [59]. This opens avenues for using a wide variety of game types for industry training. However, there is limited research in this area. From this scoping review, only one manuscript by Den Haan, et al. [11] reported on how hybrid board games can be used for industry training. Additionally, the use of hybrid board games outside the contexts of recreation, education and industry training has not been researched.

Many studies within the field of hybrid board games commented on technologies which can be utilised to enrich user experience through the digital elements of hybrid board games. The ubiquitous nature of smartphones and portable devices makes them a reliable asset to integrate with physical aspects of a board game. As researchers have shown, this removes game developers' reliance on technological hardware and allows them to utilise smartphone in-built technology such as a built-in camera, microphone or speakers with custom built software or mobile apps, augmented reality or QR codes. Alternatively, some researchers have approached hybridisation by focusing on ways in which technology can be incorporated directly into physical playing pieces or the actual board by integrating sensors or LED screens. As technology continues to evolve and new trends in technology emerge, as a response to market demand, it is likely that board game developers start routinely incorporating these as hybrid aspects of their board games.

An examination of the studies included in this scoping review offers insight into the most frequently used methodologies for researching hybrid board games. A considerable number of studies exhibited ambiguity regarding their research methodology, with those explicitly outlining their approach largely leaning towards qualitative or mixed methods.

Since board games are usually designed to be played in groups, many researchers have opted to use gameplay testing sessions as their preferred data collection instrument. This is often used in conjunction with other data collection instruments such as interviews and surveys. Focus groups, a popular data collection instrument for the related discipline of user experience design, were seldom used as they are inferior to gameplay sessions for studying hybrid board games.

A group of studies focused on game creation, attitudes, taxonomies and design guidelines (Figure 4). These studies had a conceptual focus.

## 4.2 Limitations

This scoping review had a number of limitations.

One limitation of this study is the exclusive use of the term *hybrid board games* in the search strings. While this term is widely recognised and provides a clear and consistent framework for the review, the omission of other search terms may have excluded relevant studies that use alternative terminology such as *augmented board games*, *hybrid tabletop games*, *phygital board games*, etc. The decision to use a single term was made to maintain focus and manageability, and to avoid ambiguity associated with terms that could be mistaken for other industries, such as *augmented* which is often associated with augmented reality, and *tabletop*, commonly linked to tabletop RPGs. However, this choice may have some relevant studies being overlooked.

Secondary sources have not been examined as part of this scoping review. Only manuscripts which were included in the search results of aforementioned search strings in SCOPUS, Web of Science, IEEE and ACM Digital Library were included. The only exception were several manuscripts marked as *Secondary Documents* by SCOPUS which met all of the inclusion criteria.

Grey literature was not examined in this scoping review as we were interested only in individual sources of evidence that have been published in reputable journals and conferences that used blind refereeing. Since hybrid board games are

primarily used for recreational purposes, there is a possibility that a large amount of literature in this field is non peer-reviewed and takes the form of articles published by gaming journalists or as blog/forum posts by fans of these games.

### 4.3 Conclusions

Despite the search criteria of this scoping review being intentionally broad, and the date range unrestricted, only 40 studies qualified. Unlike related fields such as video games or hybrid technologies, research on hybrid board games is still in its infancy, yet closely linked to industry output. As more hybrid board games are released, research in this area is expected to grow, with researchers disseminating their findings primarily through conference papers, although journal articles are also popular.

The research directions identified span eight broad categories, highlighting varied research foci within the field. Common research directions include *hybrid board game creation*, as well as *hybridisation of physical board games*, with the most popular research focus being *the use of hybrid board games in education and training*. Research has shown that hybrid board games are being increasingly recognised for their potential in contexts beyond recreation, particularly in the context of education and industry training.

Technologies, notably smartphones and portable devices, facilitate innovative integration of digital elements with physical board games, offering various opportunities for hybridisation.

Methodologically, qualitative and mixed methods are prevalent, reflecting the emphasis on capturing nuanced player experiences. Gameplay testing sessions emerge as a favoured data collection method, complemented by interviews and surveys.

Overall, research in the field of hybrid board games is diverse and evolving, with ongoing potential for exploration and innovation. Based on the results of this literature review, the following gaps in knowledge could be addressed by future research studies:

- Attitudes towards hybrid board games from two vantage points: from the perspective of the game developers and from the perspective of consumers. Although some researchers have explored attitudes of players, this has mostly been a side finding, not the primary focus of their studies. Therefore, the following questions need addressing:
  1. *Which aspects of board game hybridisation are embraced by consumers and why? Which ones are rejected and why?*
  2. *Which factors could alter board game designers', manufacturers' and publishers' attitudes towards incorporating digital elements into their products?*
- Further exploration of contexts where hybrid board games could be useful – studies included in this review mostly focus on hybrid board games in education. Perhaps there are other contexts yet to be researched where the use of hybrid board games could be explored further. Therefore, the following question needs addressing:
  1. *What role do hybrid board games play when used in different contexts?*

Additionally, any researchers looking to conduct their own literature review on hybrid board games should be mindful of the limitations imposed upon this scoping review. For example, researchers conducting a scoping or systematic review on this topic may opt to incorporate more search terms into their database searches to cover broader terminology, such as *augmented board games*, *hybrid tabletop games*, *phygital games*, etc. This approach ensures comprehensive coverage of the literature, capturing studies that may use different terms to describe similar concepts. Additionally, grey literature could be a valuable source of data for the purposes of conducting research into this field.

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