Review Ecosystems to access Educational XR Experiences: a Scoping Review

Shaun Bangay, Adam P.A. Cardilini, Sophie McKenzie, Maria Nicholas and Manjeet Singh

***Abstract*—Educators, developers, and other stakeholders face challenges when creating, adapting, and utilizing virtual and augmented reality (XR) experiences for teaching curriculum topics. User created reviews of these applications provide important information about their relevance and effectiveness in supporting achievement of educational outcomes. To make these reviews accessible, relevant, and useful, they must be readily available and presented in a format that supports decision-making by educators. This paper identifies best practices for developing a new review ecosystem by analyzing existing approaches to providing reviews of interactive experiences. It focuses on the form and format of these reviews, as well as the mechanisms for sharing information about experiences and identifying which ones are most effective. The paper also examines the incentives that drive review creation and maintenance, ensuring that new experiences receive attention from reviewers and that relevant information is updated when necessary. The strategies and opportunities for developing an educational XR (eduXR) review ecosystem include methods for measuring properties such as quality metrics, engaging a broad range of stakeholders in the review process, and structuring the system as a closed loop managed by feedback and incentive structures to ensure stability and productivity. Computing educators are well-positioned to lead the development of these review ecosystems, which can relate XR experiences to the potential opportunities for teaching and learning that they offer.**

***Index Terms*—review ecosystem, experiential review, virtual reality, eduXR, learning environments**

I. Introduction

A. Rationale

A range of engaging research-derived and commercial interactive games and virtual reality experiences have been developed to support teaching and learning. However, none of these are of any significance unless teachers are supported in selecting applications relevant to their curriculum topic and integrating them within their teaching plan [1]. Identifying and assessing individual applications is time consuming so reviews of these applications provide an objective proxy to curate these experiences. A review ecosystem is the environment that hosts and maintains these reviews [2].

Applications classed as games already have flourishing review ecosystems [3, 4, 5] although these are often curated to focus on entertainment value and commercial objectives rather than to identify educationally relevant concepts. Virtual reality (VR) applications include VR-based games but can include experiences designed for education and training, or for other purposes such as tourism or marketing. While some of these might be visible in existing game review sites, there is currently an opportunity to purposefully design platforms that host reviews of educational virtual reality applications to facilitate their identification, adaptation and use across a range of curriculum topics. Figure 1 illustrates that despite interest in virtual reality and an established pattern of use for game reviews there is a gap and opportunity to create a review ecosystem that caters for virtual reality reviews.

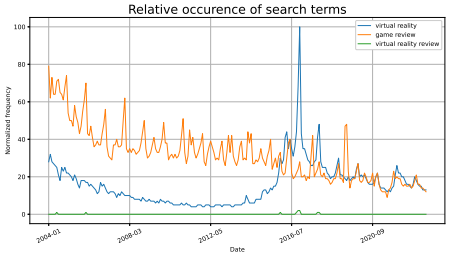

Fig. 1. Finding reviews for virtual reality experiences is challenging as illustrated using Google search trends. Despite the limited validity of this data source, it does illustrate that while "virtual reality" is a well known concept, and "game review" is also a common search term, the use of "virtual reality review" is almost nonexistent in comparison.

Academic investigation into serious games [6] does focus on educational benefits and leads to review environments such as books [7] that categorize applications according to their value in a classroom. Previous systematic literature reviews [8] have identified properties of individual consumer reviews, including the interactions between the key components of reviewer, review, recipient, channel and response. We anticipate that a viable review ecosystem is a complex system that will extend beyond commercial interests to meet the needs of a diversity of stakeholders including educators. This review focuses on identifying existing practices for building and maintaining review ecosystems for interactive applications so that these can be employed and extended to create specialized review environments.

A review ecosystem hosts game reviews and facilitates the creation of new reviews. Review ecosystems for games are well-established, but those for virtual reality experiences are either a sub-category of games or are still in their development stages where they may exist primarily as rating and ranking

Shaun Bangay is with the School of Information Technology, Deakin University, Geelong, Australia, e-mail: shaun.bangay@deakin.edu.au

Adam P.A. Cardilini is with the School of Life and Environmental Sciences, Deakin University, Geelong, Australia, e-mail: adam.cardilini@deakin.edu.au

Sophie McKenzie is with the School of Information Technology, Deakin University, Geelong, Australia, e-mail: sophie.mckenzie@deakin.edu.au

Maria Nicholas is with the School of Education, Deakin University, Geelong, Australia, e-mail: maria.n@deakin.edu.au

Manjeet Singh is with the School of Information Technology, Deakin University, Geelong, Australia, e-mail: manjeet@deakin.edu.au

systems (e.g., for SideQuest[1]). Educational virtual and augmented reality (**eduXR**) experiences have little representation within these systems. The inability of teachers, and students to assess the appropriateness eduXR experiences for their learning outcomes represents a significant barrier to the use of XR in educational settings. An educator who needs to rapidly identify and deploy such experiences when teaching a specific classroom topic requires an eduXR review ecosystem with reviews that are created and formatted for this purpose. *The challenge to be addressed is to systematically design and build a successful review ecosystem that exposes the insights captured during the review process, and that supports stakeholder and community focus beyond gaming and commerce by reporting on issues relevant to education and XR.* This *literature review* catalogs existing best practices to identify review ecosystem components that can be used as the starting point for achieving this goal.

Teachers face particular challenges in using existing review ecosystems to identify experiences that support their classes. The benefits of technology integration, and especially XR [9, 10, 11], are well documented and include allowing students to intensify their engagement with concepts [12] and engage in both formal and non-formal learning [13]. However, after the challenge of managing equipment, the most significant technology integration hurdles for teachers are the loss of control, and the need for support and training in using new experiences [1, 14, 15]. Integration of XR applications, in particular, benefits from social support mechanisms [16]. Unlike game players who read reviews at their leisure, most teachers are time poor and need to find relevant information efficiently [15]. Teachers need specific and relevant information to know whether a given experience can be used within their teaching environment and their available equipment. The best review ecosystem is one focused on the needs of teachers and that builds a supportive community of peers [1]. Information in reviews needs to be authentic, accurate and relevant. The educational merits of particular applications need to have been validated in practice. The outcomes of this paper are useful for creating a range of review ecosystems and are applied in section V-B to provide the means to design a solution that addresses these requirements.

B. Terminology

We employ the term eduXR to refer to virtual and augmented reality experiences (and any blend of these to produce a mixed reality or extended reality experience [17]) that are intended, or can be repurposed, for educational benefits. Such experiences enhance the perception of the physical reality experienced by a user with synthetic virtual content mediated by a computer. The boundary between XR and other forms of interactive 3D experiences is fluid but for the purposes of this paper we focus on XR experiences that deliberately utilize technologies created for the purpose of achieving participant immersion and that classify themselves as XR.

Serious games is a complementary concept to eduXR, with the relationship being illustrated in Figure 2. The terms are not mutually exclusive as some XR experiences can be games, although there are other forms (e.g., passive entertainment, collaboration tools, virtual tourism, educational experiences) that are not games, just as many games are not intended to be XR experiences. Serious games provide value beyond entertainment and are frequently used as a tool to support learning [6], just as eduXR focuses on the educational opportunities within XR. Neither the term seriousXR or eduXR appears to be in widespread use at present although the latter term is used for some related products.

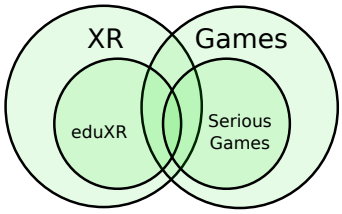

Fig. 2. The overlap between concepts related to eduXR and serious games.

The word review is used in this paper to describe a report intended to describe and rate an experience. To avoid confusion this form of review will be referred to as an *experiential review*. This is distinct from a literature review, such as this scoping review and the systematic literature reviews in many of the sources that we cite. As such, usage in the latter context will be described as a *literature review*. The type of literature review used for this paper - a scoping review [18] differs from a systematic review in that it aims to identify "what is known about a particular concept". In this case, we aim to identify and describe those concepts applied to managing game reviews that can be used as foundational principles for creating a stable and functional review environment that identifies properties and relationships across multiple eduXR applications.

C. Objectives

The goals for this paper are to:

1) Identify and describe trends related to current practices in preparing, presenting and maintaining a set of *experiential review*s within an *experiential review* ecosystem by using a *literature review* methodology. This involves cataloging existing strategies reported during research into game review ecosystems.
2) Present practices that can be used to establish and enhance the *experiential review* ecosystem for eduXR experiences. Such guidelines would then enable further research into review ecosystems and how they can take advantage of XR technologies. These practices and any opportunities identified can be used to create review ecosystems appropriate to a range of specialized contexts.

The strategies and practices identified are intended to support the design and development of a review ecosystem for eduXR that meets the needs of educators and other stakeholders. The design team need to consider how best to represent an *experiential review* (the form and format), ensure the process of creating and presenting a review matches the needs of the

[1]https://sidequestvr.com/

stakeholders (utilization), and must establish the mechanisms used to produce a stable, complex, control system (ecosystem management). This *literature review* meets these needs by extracting this information from existing research into review ecosystems.

II. Method

This scoping review aims to identify practices used to build and maintain an *experiential review* ecosystem by identifying practices used in the most closely related established equivalent; that used for computer games. The search process identifies reports analyzing existing practices. As a scoping review [19] the focus is to report the extent of research relevant to creating eduXR review ecosystems, to summarize research findings and to describe approaches that can be used as a foundation to further research in this area.

A. Protocol

The protocol used aligns with the PRISMA process as adapted for scoping reviews [18]. The structure of the scoping review aligns with the broad objectives of analyzing game review ecosystems and synthesizing guidelines for developing eduXR review ecosystems [19].

The literature collection (section II-D) and analysis (section II-G) were iterated over two phases. The first phase refines the search terms and the analysis process. The second phase performs a clearly defined search and uses triangulation strategies to confirm adequate coverage. The analysis extracts information on the strategies used to create review ecosystems under the categories of *form, usage and ecosystem management* to categorize the nature of the reviews, the ways in which they are used, and the ecosystem structures and mechanisms. These topics are organized to identify trends and presented as options for designing review ecosystems.

B. Eligibility criteria

As a scoping review the goal is ensuring that the diversity of the topic is reflected by capturing insights from all of the sources regardless of quality [19]. All search results were subject to the same screening based only on the topics covered in the documents. Each database provides an inherent quality screening based on its standards for inclusion. A "review ecosystem" is not an established concept so the search process selects research that utilizes collections of reviews of interactive applications.

C. Information sources

As the fields of eduXR and computer games are cross disciplinary no restrictions were imposed on the source of publications used. This *literature review* utilizes two principal multidisciplinary search systems [20]: Web of Science (WoS) and Scopus. The phase 1 search took place in August 2022, with phase 2 updating and extending this in June 2023.

D. Search

The few eduXR review ecosystems that exist are directly derived from game review sites and so little literature exists that describes the properties of XR reviews (see section II-D2 below).

1) Phase 1: Establish search criteria: The phase 1 search aimed to trial search terms. The terms used for each of the databases searched are:

Web of Science: "game OR gaming AND review*", "gaming review".

Scopus: "game OR gaming AND review*".[2]

The Web of Science search results were grouped in sets of 50 and each article screened (as per section II-E). The search was halted when a page of 50 entries yielded zero relevant results (n = 350 entries), yielding 15 relevant entries at the conclusion of the search. The Scopus search was used to corroborate this, yielding 1 further relevant entry (n = 200).

The word "review" identifies any paper that provides a *literature review* covering any aspect of gaming. The phase 1 search does include *literature review*s that just categorize and analyze games. These papers describe relevant game properties but are screened out in phase 2 to preserve the focus on collections of reviews.

2) Phase 2: Exhaustive search: The phase 1 results indicate that relevant papers use the word "reviews" (plural) in the title. The following search terms applied to paper titles provide few useful results:

- "virtual reality" AND reviews*: Web of Science returns 21 results of which 2 are relevant. The other results relate either to design reviews (product reviews conducted within virtual reality) or meta-reviews (reviews of *literature review*s). Scopus returns 28 documents of which 2 sources are relevant.
- "augmented reality" AND reviews*: Web of Science returns 6 results of which 1 is relevant. Scopus returns 10 results of which 1 is relevant. Discarded results cover the use of AR to present reviews of other products.

Since the number of results was regarded as insufficient to inform the design of a review ecosystem, the term "game" is used as well. XR applications are typically hosted and reviewed on gaming platforms. Hence the phase 2 search focused the search using:

Web of Science: "game*" AND "reviews" (in title).

Scopus: TITLE ("game" AND {reviews}).

Web of Science returns 52 results of which 32 pass screening. Scopus yields 116 documents with 50 relevant, and with 5 papers discarded as they were identified as earlier versions of later research that had already been included. This supports the hypothesis that a focus on game review ecosystems provides greater insight than analysis of the fledgling XR review systems.

[2]The observant reader will note that the search term should actually be: "(game OR gaming) AND review*". The consequence of this correction was tested. In this case the outcome is unchanged because the results are sorted by relevance which largely compensates for the difference. The original search actually produces a greater number and variety of results within the first (n = 350) results, which is helpful for this exploratory phase.

Phase 1 only	[21, 22, 23, 24, 25, 26, 27, 28, 29]
Phase 1 and 2	[5, 30, 31, 32, 33, 4, 3]
Phase 2 only (Web of Science and Scopus)	[34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57]
Phase 2 only (Web of Science only)	[58]
Phase 2 only (Scopus only)	[59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77]
Virtual Reality	[47, 78]
Augmented Reality	[79]
Snowballing	[80, 81, 82, 83, 84, 85, 86]

Fig. 3. Results returned from each search stage.

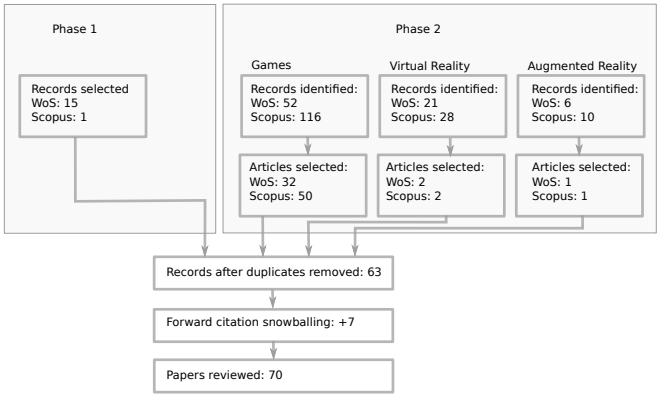

Fig. 4. Flow diagram summarizing the search and screening steps.

Educational games and XR experiences are not precluded by these search terms. Topics related to education are identified and extracted during analysis of each of the papers.

Hence this *literature review* analyzes research into gaming review ecosystems and extrapolates from this to the processes applicable to XR reviews.

3) Phase 3: Snowballing and saturation: Saturation is assessed by screening all the papers that cite those identified, using the links provided in the databases searched. This snowballing process ensures that recent developments and similar *literature review*s are also captured. Snowballing identified a further 7 papers. Reference lists within the selected papers are examined during analysis and screened similarly. No additional sources were included although some references provided insights that are used in the discussion. This process is summarized in Figure 4 with the papers identified listed in Figure 3. The small number of new papers added at this stage, and the frequent recurrence of previously found papers suggests that the search process has identified all relevant sources meeting the screening requirements. Phase 1 provided a diverse set of sources which contribute to the breadth of the review. Phase 2 is focused and exhaustive and is dominated by research into automated mining of review text.

Reviewer feedback suggested a further verification step involving taking the 1511 results for the WoS title search: "game*" AND "review*" and screening this against the criteria described using title, keywords and abstract. This produced the same 32 papers found using the phase 2 search, 4 new papers published since that search and 1 further paper that used "game review texts" rather than "game reviews" in the title. This additional triangulation suggests the literature included is complete. A small number of papers outside the screening criteria but that elaborate on the identified themes around educational- and peer-review were also added at this point.

E. Selection of sources of evidence

The phase 1 search sampled the literature by assessing titles to determine if each article referred to or explored how to conduct an *experiential review* or discussed the features of an *experiential review*. The abstract was cross referenced when additional information was needed. Literature reviews about gaming and/or associated disorders (e.g., game addiction, sleep disorders or gambling), or game developers, were excluded from the final selection. This sample provided guidance on shaping the selection criteria for the phase 2 search.

In phase 2 the selection criteria applied to screening the paper titles and abstracts ensure that the paper is focused on games or XR. The focus of the paper needs to provide insight into how properties of *collections* of *experiential review*s are being analyzed. The paper must refer to the use of *experiential review*s in any form or medium. Generic (i.e., unrelated to game properties) discussions (e.g., on social media, live streams or chat logs), use of game marketing and descriptive materials, investigation of other forms of engagement measures (e.g., psychophysiological measures while playing) and studies that use reviews without justification are excluded. This excludes analysis of reviews that describes *only* model fitting (such as text mining, sentiment distributions e.g., [87] or natural language properties). Other forms of product, including other mobile applications, are excluded. Reviews of other products presented using XR are excluded.

Game evaluations are a form of review that are adequately covered by other *literature review*s [22, 23, 24]. Results from phase 1 are retained but are screened out by the phase 2 criteria to focus on collections of reviews. This *literature review* is lenient in screening and aims to include articles if they can contribute new insights into managing a review ecosystem. Since no meta-analysis is required rigorous sampling is not necessary.

F. Data items

The focus of the analysis is to identify the current state of research into review ecosystems. The information required, as defined in section I-C), specifies the following topics as necessary to guide the design and development of review ecosystems:

1) **Form of the *experiential review***: This category covers the way information in the review is presented, and the trade-off between presenting a review that is interesting, informative and specific to the eduXR experience against

populating a table of standardized entries that can easily be searched or compared.
   - **Format**: The way in which the review is presented (e.g., written documents, video reviews).
   - **Template**: Do reviews follow a consistent structure and, if so, what are the elements of this structure.
   - **Focus**: The motivation for doing the review.
   - **Field**: EduXR overlaps with several other fields, including simulation, games, and serious games. The material reviewed may concentrate on one or more of these.
2) **Review utilization**: This category identifies the ways in which the review is useful. This is inferred from hints provided in each source where it is not explicit.
   - **Target audience**: Who is the review intended for?
   - **Usage**: What the review is used for, and how it is used for that purpose.
   - **Education**: How reviews contribute educational value and the educational aspects that are measured in a review.
   - **Mechanics**: How the review is actually created.
3) **Ecosystem management**: Individual reviews are expected to have significantly more value when they exist in a shared environment (e.g., by using them to compare different eduXR experiences).
   - **Structure**: The components of the ecosystem (e.g., groupings of stakeholders).
   - **Incentives**: The mechanisms employed to ensure new eduXR experiences are reviewed, and that the reviews follow conventions and standards.
   - **Value**: The rewards and the costs associated with the review ecosystem. The hypothesis being assessed is that any stable ecosystem should have rewards exceed costs, and that all stakeholder groups should perceive a net gain.
   - **Quality**: Mechanisms to compare or evaluate reviews.
   - **Environment**: The environment in which the review lives, including the sites that host them.
   - **Viability**: The lifespan and ongoing viability of a review ecosystem.
   - **Challenges**: The difficulties associated with the creation of reviews and management of review ecosystems.

The selected papers were reviewed to identify any information relevant to each of the topics. A spreadsheet was prepared with a column for each topic. The material from each paper that is relevant to each topic is recorded in the spreadsheet. The analysis is performed by one member of review team reviewing all papers to ensure consistency in extracting information from the papers. The information extracted is then reviewed by all the other authors and the different options are listed in section III.

G. Synthesis of results

Synthesis identifies the trends or alternative approaches for each topic presented in section IV. These present the options available when designing and implementing a new review ecosystem intended to achieve a particular purpose. Subsequent discussion points are approved by all authors and used to identify opportunities to focus further research to advance best practice in developing *experiential review*s for eduXR experiences.

III. Analysis

A. Review ecosystems

What is a review? The concept of an *experiential review* differs widely across the literature that was surveyed. The search terms used on academic literature databases identify many systematic literature reviews during phase 1. The acceptance criteria require that the papers be relevant to gaming reviews with the consequence that several papers apply the term to both forms of review within a single paper. A review can be conducted both as an *experiential review*: a document describing particular properties of one game [24, 3, 32, 4, 21, 5, 33, 30], but also as a *literature review* which identify common trends across several sources [27, 23]. The latter interpretation identifies a potential gap in the game review ecosystem as typical game reviews describe only a single game. Other forms of review are possible, e.g., heuristic evaluation [71].

Data mining [30, 3, 36, 37, 39, 41, 46, 49, 52, 69, 84] is used to identify features of game reviews that predict game properties such as ratings. An opportunity still exists to compare trends and commonalities across different games based on such features. Game reviews use specific terminology, humour and sarcasm, and reviewers have varied motivations and incentives, which provides a challenge when distilling information from collections of reviews [3, 36, 38, 74]. This is balanced by the reward of greater value resulting from the collective value of the review ecosystem [39, 53]. Review ecosystems equalize the power imbalance between large commercial operations and individual players [41], and provide an opportunity to reason about and compare reviews [43, 58, 54, 78, 72, 64, 69, 60, 74, 76, 59, 2, 81, 8, 88].

The purpose of a review varies. Reviewers can have specific agendas such as: providing a description and recommendation for a game [32, 30, 67, 61, 83], presenting personal experiences [34, 44], causing game sales [75], identifying a relevant educational resource [29], reporting on educational properties of a game [22] or how the game functions for learning particular topics (e.g., software project management [24], computing education [27] or employee selection [89]), the game's value as an assessment platform [25, 24, 89, 90, 91], measuring properties and quality of the game [3, 4, 21, 5, 29, 35, 37, 42, 50, 65, 77, 63, 92, 84] or as a quality control process [26], providing feedback to game designers and developers [28, 47, 48, 66, 68, 80, 93], informing purchase decisions [33, 39, 55, 57], understanding the player and their experience [31, 40, 51, 79, 62, 73, 70, 82, 85, 86, 94] or assessing and influencing the play experience [23, 45, 52, 56, 95]. A review is a way of experiencing an intangible product that cannot be tested before purchase [3] and bookends the game experience with anticipation and priming prior and sharing afterwards.

B. Form of the review

W e investigate the properties of individual reviews to develop insight into the mechanisms used to create and manage review ecosystems. Specifically we identify how reviews are presented, what information they contain and what they provide.

1) Format: The form and format of reviews reported, as summarized in Figure 5, is typically as a written document although these exist in several forms. Several sources review and analyze academic literature in the form of case studies, and these individual case studies are reviews of an experience. The structure of a case study is, however, dominated by formats dictated by the case study process rather than the need to consistently report on the system being studied. While most written reviews contain at least some free-form text a few sources use, or recommend using, particular fields as a template for providing reviews. Game review sites usually provide limited facilities for formatting the free-form review text [4] rather than supporting a recommended document structure with consistent headings. Review writing varies in rigour from formal reports produced by professional reviewers [55, 59] to written reviews created by other members of the community, and then to short informal comments provided on social media platforms [80]. Allowing only constructive feedback enhances the value of the review [90].

Most of the reviews selected for analysis reflect a single culture and language. This choice conveniently simplifies any processing of the natural language text. A few studies do explicitly analyze reviews presented in a range of languages [36] and investigate whether cultural conventions influence the way information is expressed in reviews [51] and consequently whether it is meaningful to compare scores generated for these reviews.

Reviews in other formats are comparatively rare with surprisingly few mentions of video reviews [5, 39, 8] given the popularity of social media sites for video sharing and streaming of game play. Content created in 3D (in this case architectural models [26] but relevant to games and XR) could be reviewed in the same 3D format using collaborative annotation in a shared virtual space. A further non-traditional form of review [31] involves deriving insight into game play by mediating the game experience through recordings of play and discussion with a researcher who then reports on the outcome. This latter process is distinctive in that the review is not constructed directly by the player, and that the review is linked to a particular play session.

2) Template: Every source identifies particular elements of a review that should be common to all reviews. These relate to the description of the product, and include the name, genre, and an aggregation of the previous review ratings. The remaining categories of review element vary depending on the context and are summarized in Figure 6.

Player properties are provided by dedicated game review sites and report the qualifications of the player (who is assumed to be the author of the review). Experience is measured in terms of previous reviews created and by hours of game play, reflecting the extent to which a review represents first impressions or a level of competence in the game.

Review formats
Written document (academic paper): [25, 24, 23]
Written document (fixed format/template): [4, 27, 30, 28, 29, 52, 91]
Written document (unrestricted prose): [3, 32, 4, 21, 5, 33, 22, 35, 36, 37, 40, 41, 43, 58, 44, 45, 46, 47, 48, 49, 50, 53, 54, 56, 57, 78, 79, 62, 72, 65, 64, 66, 73, 69, 67, 60, 68, 74, 77, 70, 61, 59, 80, 92, 81, 82, 83, 84, 85, 86, 88, 89, 96, 93, 94, 97, 90]
Other: video [5, 39, 8], process using video and screen recordings and interviews [31], images [76, 8], 3D virtual environment [26], numeric score/rating [34, 55, 71, 63, 75, 98, 99]

Fig. 5. Format: the forms and formats of *experiential reviews*

A significant category is the elements that describe properties of the game. This is a rich and diverse topic and the merits of these properties are better suited to literature reviews that specialize in game analysis. Professional reviewers provide detailed and objective reports while amateurs present personal and emotional reviews [74]. Several sources make explicit reference to the quality of the game. Since a review can be expected to serve as a quality indicator, this particular game property is discussed in its own category.

While not all reviews are expected to focus on educational applications, there are sufficiently many represented to justify categories relating to these review topics. These topics describe the educational content, and the degree to which the experience supports learning outcomes. Gamification terms are frequent where the experience is intended to provide motivation, engagement, clear goals, and feedback to support learning. The use of the game as an assessment tool merits its own category which concentrates on measuring achievement before and after the experience.

Reviews also serve to provide information about the developer of the game although the sole source [28] assumes this information is provided by the developers themselves.

The review fields dictate the way the review is conducted. For example, reviews may be conducted at key stages of exposure to the experience [25], or be required to provide information to validate the rigour of the review [27]. Review analysis shows that the structure of the review correlates with quality of the experience. For example, the format differs between positive and negative reviews [5].

Several sources reason explicitly about the structure of the review and what information it should contain. This is particularly relevant when considering reviews published as case studies, and the need to meet acceptance criteria before these can be utilized within a systematic review [24, 21, 22, 23]. The analysis [79] classifies the focus of a review into the categories of: information giving, information seeking, problem solving and requesting feature changes. Correlations can exist between the topics presented. For example, negative reviews often focus on aspects of design rather than technical problems [72]. Amateur reviews tend to be produced in isolation, and miss the opportunity to present similarities to other games, or to employ

a standardized vocabulary to describe game concepts [67]. In contrast, professional reviewers produce many reviews and are able to draw connections to previous versions and other games [76].

The lack of a consistent review template [2] has the consequence that analysis of sets of reviews either concentrates on just the numerical scores (ignoring the text), performs manual qualitative analysis on a small number of reviews, or employs automated natural language processing to identify themes as an initial step [80].

3) Focus: The reasons for performing the review vary as much as the structure and format of reviews. The obvious purpose of a game review is to identify pleasurable experiences [59], rate game features [54] and inform other players of the nature of the game [42] but even these goals has their subtleties. The reviews may be directed at peers [21, 98, 90], in which case communication is targeted at others with equivalent interests and represents a voluntary contribution to a community of like-minded individuals [40, 46, 80, 86, 100, 101, 102]. Reviews are a way to achieve recognition and standing within such communities [43, 56, 84], and provide a forum to relate game play themes to the reviewer's own lived experience [53, 65, 94] or personal agenda [78, 68, 75]. Reviews might be created just because of a need for the insights that they provide [2]. Experienced gamers [81] and professional reviewers produce longer and more complex reviews [36] and describe the game in the context of its predecessors [76]. Reviews can influence the way in which a game is perceived, colour the play experience [33] and produce more sophisticated and aware players [48]. Casual reviewers often provide reviews for old games, suggesting an element of nostalgia [74].

Reviews influence purchasing decisions so review ecosystems develop that facilitate this [32, 4, 52]. From this perspective, reviews are tools to influence purchase decisions [39, 51, 57, 60, 8]. Reviews provide a mechanism to gain insights into intangible products, such as games, where it is not possible to test the product before buying [41]. Reviews are more informative than the game descriptions provided by publishers [67], and provide balance to the marketing efforts of large companies [81] by allowing individuals to reach large numbers of players [86]. Reviewers act as gatekeepers to ensure quality [99]. Positive reviews correlate to the success of a game with review score used as a metric when evaluating game design and development teams [58, 66]. Games with low numbers of reviews may be sold at a discount to encourage more reviews [57]. Trust in reviews is highest for voluntary reviews [72] as fake reviews are usually created for payment [64, 38]. Aggregation of reviews (e.g., via a systematic review) reduces bias [2].

However, game reviews can also be a way of communicating with the design and development team [5], to effect change in the game [37, 93]. Review processes that encourage the player to think as a designer [31] allow the player to gain greater insight into their own understanding of the game. Design insights are more valuable when the reviewer has greater experience with the field and technology [47]. Game designers mine reviews to get insight into player preferences [35, 39, 60]. Reviews also provide a support channel to report problems, request features or ask questions [79] of developers or other players. Heuristic reviews are conducted within the development team to test the design [71].

Serious games, or those for educational purposes, have additional goals and require reviews that assess how well they achieve these goals [25, 24, 26] or suggest educational improvements [79]. The review is used to directly assess the success of an educational game [22], particularly if the structure of the review is specified in advance [27]. Standardizing the format of the review allows it to be used as an assessment form [24], and a literature review of published reviews then helps identify trends and themes across these reviews. Qualitative elements of the review provide insight into good game design and game-based training principles that can be applied in future game designs [28].

Our own motivation: using reviews to identify relevant educational resources is shared [29] where a standardized serious game metadata format is employed to describe serious games so teachers/therapists can find suitable games to use in class/therapy.

4) Field: The areas that *experiential review*s target are summarized in Figure 7. As may be expected based on the search terms used, most reviews relate to games, with a smaller subset relating to virtual and augmented reality. Despite the screening criteria mobile games and applications are also represented as these tend to overlap with games and XR applications.

While most of these analyses of *experiential review*s cover games in general several do restrict their focus to particular areas within this field in order to extract targeted insights. These foci cover particular aspects of games such as genres (role playing, souls-like, multiplayer) and purposes such as serious, educational, simulation, and therapy. The few XR applications are all specialized, covering areas such as games, social collaboration, health and education.

The reviews with a defined purpose cover areas of game design such as play experience [31, 42], narrative [67], player expectations [48], addiction [44] and sexuality and gender [53]. Serious and educational games are those with an educational focus and where entertainment is a secondary outcome. Educational topics covered [25, 24, 22, 27, 28, 29] include cultural, professional, and social skills, and life decision support training [24], computing education [27] and ethics [50]. Game reviews do also provide insight into a wide range of other areas including information systems [25, 8], computer science [25, 27], engineering [25], architecture [26], journalism [76], economics [25], marketing [51, 8], and health [24, 29, 2, 80]. Review ecosystems consisting of collections of reviews provide insight into the domain of the reviews while also being relevant to many other overlapping domains.

C. Review utilization

The next step in understanding what sustains a review ecosystem is to ask who uses reviews, what they are used for and how they are used.

1) Target audience: We make a loose distinction between customers and players although these two categories overlap.

Information category	Topics
Product metadata	application domain, types of game [24, 96], recommendation [40, 3, 89], author ID, got game for free, got game before release [3], name of game [54, 32], category, version, ranking (in downloads), star ratings, number of reviews [32], price [32, 8], game information [21], genre [77, 76], system requirements [77, 76], brief text overview, awards received, link to site (URL), target age group [28], tags [77], community size, special events, time to win [95]
Player/reviewer properties	time played, products owned [3, 50, 54, 94, 95], playing hours [5, 84], recommended/not recommended, number of played games, number of reviews posted, number of hours playing before writing a review, negativity of reviews [5], details of the subjects using the experience, details of reviewer [23]
Review content	description [59], pros, cons, suggestions, bug reports [5, 39, 52], rating (score) [4, 33, 47, 51, 56, 57, 78, 66, 74, 70, 61, 92, 94], information for other users [73], technical, design and service issues [79, 59], how to maximize value [59]
Gaming properties	acceptance [24], accessories [30], achievement [30], action language [21], assessment [21], audio [53, 60, 76, 75, 85], background [85], balance [28], conflict/challenge[21, 22, 27, 86], content [82], characters [53, 84, 85], control[21, 27, 82], crashes [82, 84], customization [59], educational balance [29], effect on user motivation[24], engagement [27], enjoyment[24, 27], environment[21, 59], experience [68], feedback [28, 85], fit for purpose [28], flow [22], fun [22, 27], game design[24, 28, 59, 85], game fiction[21, 30, 28, 53, 59, 85, 88], game play [60, 76, 75, 59, 82, 88], immersion[21, 22, 27], influence [68], mechanics [53], motivation [28], multiplayer [86], performance[24, 82], physics [86], playability[24, 53], player experience [29], price [53, 59, 85], progress [68], realism [27], recommendation [27], rules/goals, [21, 86], social interaction [27, 30, 53, 68, 59], uniqueness [46, 53], usability [24, 21, 22, 27, 59], variety [59, 86], visual/value [30, 60, 76, 75, 68, 85, 88]
Game quality	quality characteristics/measures [24, 58], value judgement, comparisons [21], quality [27, 29]
Educational content and value	educational elements, learning outcomes, engages users, achieving intended result, social impact, affect on cognitive behaviour [24], learning, social interaction, relevance, goal clarity, motivation [22] student learning, quality of instruction, motivation, instruction [27], use for training, context, elements of the game [28], serious/goal relevance (characterizing goal, clear goal, indispensability of goal, content correctness, feedback on progress, reward, proof of effectiveness) [29], rubric [91]
Educational assessment	categories of assessment (summative, formative, end-of-game, stealth, scoring, external) [25], learning (competence before and after playing) [27]
Review text features	number of paragraphs, readability, sentiment, time span, similarity [3], fun, information richness, perceived value, after sales support, stability, challenge, expectation, promotion, online community, accuracy, special event, style of game, innovation, sustainability [32], writing style features, content features [4], emotion [50], language [54, 66]
Developer feedback	development methodology, challenges, authenticity, learning considerations, team composition (all stakeholders), deployment, hardware impact, alternative uses for the game [28, 66], discussion about design decisions [59], developer response to review [89], coding standard [97]
Review processes	structured as: phases of play (preparation, introduction, interaction, conclusion) [25], based on review outcome (positive/negative), indie/non-indie, early access, free to play, when posted [5], factors evaluated, research design, methods, data collection, sample sizes, replication, data analysis [27], social influence (within the review process) [30]
Meta review (properties of the review)	how evaluation is conducted, population size [24], value/helpfulness of the review [43, 54, 60, 74], humour rating [66], game information, text of the review [21], clearly defined approach, with empirical evaluation [22], review format (new structure, using templates, adapting templates, custom) [23], biased or fake [64], reviewer history [81]
Other	compliance with various codes, maintenance requirements [26], therapeutic value [65]

Fig. 6. Template: elements expected in an *experiential review*

Application category	Sub-category
games	any [3, 4, 31, 21, 5, 33, 30, 34, 36, 37, 39, 42, 43, 58, 45, 46, 48, 49, 52, 53, 55, 57, 62, 64, 69, 67, 60, 68, 74, 77, 70, 61, 76, 71, 59, 63, 75, 81, 83, 85, 86, 88, 96, 93, 94, 95], souls-like [54], PUBG [66]
	any mobile [32, 5, 56], mobile role playing [41]
	desktop [56]
	multiplayer [72]
	serious [23, 29, 24, 35, 80, 89], educational [22, 27, 28, 24, 44, 50]
	simulation [25]
	therapy [65]
virtual reality	games [40, 82]
	exergames [47]
	social and collaborative [84]
	relaxation and meditation [78]
augmented reality	mobile games [73]
	educational [79]
mobile applications	[92]
game-related settings	creative artifacts [98], programming [97], game studies [90]

Fig. 7. Field: application areas for *experiential review*s

Sector	Audience	Reason for using/creating review
Game production	Designers	Ensuring assessment in simulation games is accurate [25]
		Understanding what makes an effective design [21, 26, 30, 48, 62, 63]
	Developers	Understanding players and how to improve a game [5, 28, 37, 39, 94]
		As a measure of the success of a game [33, 22, 27]
		As a way to receive feedback from players [41, 66, 86, 89, 97]
	Customers	Making purchasing decisions [3, 32, 30, 43, 58, 53, 55, 57, 71, 59, 75, 8]
	Publishers	To influence commercial outcomes (e.g., manage game evolution, fake reviews) [64, 38, 93]
	Reviewers	Contribute to a review ecosystem [4]
		Measuring the value of a game [21]
		Communicating with others in a player community [21, 51, 52, 72, 60, 76, 84, 85]
		Self-expression and developing personal standing in the community [67, 68, 74, 86]
	Players	Reflecting on own play to improve experience [31, 48]
		As a way to assess game quality prior to purchase [33, 34, 35, 39, 40, 41, 58, 63]
		To receive information and advice [53, 95]
Education and training	Teachers	Using games with validated assessment [25, 22]
		To choose appropriate educational resources [27, 29]
	Students	Using effective resources when learning [22, 23]
	Peers	Peer feedback [90, 91]
Research	Academics	Research into properties of games [25, 24, 40, 96]
	Publishers	Process of sharing research [99, 101, 102]

Fig. 8. Audience categories for *experiential review*s

Customers utilize reviews as recommendations regarding financial decisions while players also use them to decide how to invest time and effort to maximize rewards from game play [33]. Player value includes benefits beyond just identifying quality of the game. Reviews provide concepts, ideas and insights that enhance the overall ability and sophistication of a game player. Reviews also provide specific information about strategies and opportunities that exist in the experience being reviewed, and that might have otherwise been overlooked.

Similarly, reviewers (particularly amateur reviewers) are also members of the player community. However, in their role as reviewers their focus is on participating in the review ecosystem. Here they provide feedback to their peers and use reviews to develop environments in which they can explore their interests (playing games) and to develop community standing. The target audience may be global, allowing reviewers to have significant impact [81], or local where the reviewer writes for their friends [85] or those with similar cultural backgrounds [51].

The target audience identified in Figure 8 covers diverse areas of the game production and deployment pipeline. At each stage, a review provides a form of feedback. This provides insights to designers and allows players to communicate with the developers of their games. Game producers rely on reviews to inform players and influence their purchasing decisions. Research academics producing case studies or game analysis papers have similar motivations but within a more restricted community. The review ecosystems that have developed to support *literature review*s can be self-sustaining, generating new reviews even when no audience need has been identified [2].

Educators and students are the other audience groups that are identified in this analysis. Reviews satisfy their needs by providing a screening mechanism to identify relevant game experiences and to validate their quality.

2) Usage: The Usage category is similar to Focus (section III-B3), with the key difference being perspective: the review author provides focus while the review consumer finds uses. Often these two perspectives are not explicitly distinguished, with usage being focused around: supporting purchase recom-

mendations [3, 32, 4, 58, 52, 57, 64, 38, 77, 63], providing insight to players [31, 33, 47], rating and ranking games [21, 68, 88], classifying and cataloging games [67], assessing and evaluating games [25, 24, 23], providing feedback to the game developers [5, 27, 28, 81, 94, 97], predicting game sales [51, 72, 74, 75, 86], and supporting the use of the game as an educational tool [22, 27, 29, 79].

Reviews can be critical in determining the success or failure of a product [98, 99, 101]. They are preferred over other sources of information because they are considered trustworthy [64, 8], because they highlight value [54], and because they provide objective information based on actual personal experience [34, 45, 46, 56] rather than marketing hype [41, 57]. Reviews reveal information that may be missed during testing or user experience evaluation [48] such as aspects of the product most significant to users [49] or how players reason about games [68, 77, 80, 84]. Poor reviews can influence perceptions, even for existing players [95].

Collections of reviews are frequently data mined to extract insights related to the experiences being reviewed. A range of game related properties are derived through analysis and aggregation of reviews such as: game quality [35], playability [46], user sentiment [70], treatment efficacy [2], and developer performance [58]. Review properties can be a proxy for game metrics once correlations between the review characteristics and the game measure are established [53]. For example, longer reviews tend to correspond to lower levels of satisfaction with the game [30], and some review properties correlate with moral game themes [50]. Reviews themselves are used as a proxy for experiencing a game before purchase [68, 92, 81]. Rules for product design can be inferred from collections of reviews [62]. Numerical scores based on review features support efficient ranking and game comparisons [60].

Value is created when researchers analyze patterns of reviews to identify insights that might emerge from the review *ecosystem* [21]. Review ecosystems provide an ideal research data source where a large amount of data has already been collected, and without influence from the research team [65, 66, 96], and that can provide insight into the community, its history and its conventions [76, 59]. Reviews serve as a feedback mechanism and can be regarded as a communication mechanism that ensures the diverse perspectives of specialist groups [27, 90] and collective opinions [45, 52, 72, 89] are shared to achieve consensus [92]. Having specialist stakeholders review a design is typical within an organization and identifies issues prior to release [71]. The benefits of review are implicit in a game review ecosystem where insights from players and educators is fed back to developers to report bugs and suggest improvements [36, 37, 39, 52, 79] and solutions [41]. For eduXR experiences the reviews reveal human interface issues, motion sickness and problems with interaction affordances [40]. Suggestion made within reviews are a form of free customer support [43] and product advertising [38, 86]. The reviews themselves can be used as a training tool for developing review writing skills [28, 91] and as training in identifying the attributes to consider when evaluating a system.

3) Education: A goal of this work is to investigate how game review ecosystem concepts translate to eduXR. While education was not explicitly included in the search criteria, education is still a strong theme in a number of the sources identified. Only three of the sources identified use the word "education" in their titles, although several others are published in journals associated with this theme.

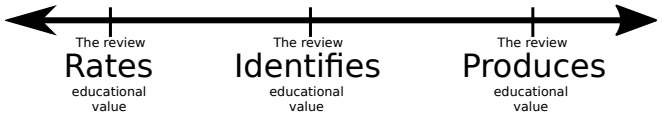

Fig. 9. The continuum of educational purposes of reviews.

The aspects of education in the reviews varies over the continuum shown in Figure 9 ranging from measuring educational properties at one end, to the review being part of the educational process at the other end. These educational properties are used to make decisions about the relevance of the overall experience (its "fit for purpose") [27] and whether it authentically conveys the intended skills, knowledge [29] and assessment [89]. Narrative games implicitly provide educational value through their stories and this can be revealed in reviews [67]. Augmented reality is a significant educational technology and reviews for these experiences report on the associated educational area and level. However, such educational branding can also be misused to target children as an audience [79].

Further along the continuum is where the review reports on individual educational qualities, such as realism, experiential learning through play or skills such as decision making and team work [25], measures of student learning or quality of materials [22], game elements and their value [48], or learning objectives and scaffolding [28]. Reporting on the game teaching particular topics is central on the continuum. Here the focus is on content such as software project management [24], or where the review structure defines best practices in reporting on game usability [23].

The far side of the continuum is the educational value provided by the review process itself. Reviews provide feedback to correct and refine designs [26, 42, 48, 97, 91] and the reviewing process enhances understanding of topics such as play [31]. Reviews written by learners provide insight into the educational value that they perceive [35, 51, 90]. Students should learn to write reviews before learning to develop the artifacts that would be reviewed [90]. Filling in a questionnaire to generate an *experiential review* is used to both evaluate a learning experience and provides a mechanism for students to self-assess the learning achieved [27].

4) Mechanics: The processes for creating reviews can be reused when developing new review ecosystems. The following themes emerged among the literature reviewed:

- **Sources of information**: Reviews are created by players based on their experience of playing the game [21, 30], as an assessment of the product [51], or through an analysis of the design [26]. Typically only a single experience is reviewed [42] leaving opportunities for reviews that compare and contrast several experiences. The review is an opinion that may represent the reviewer's mental

model and preconceptions of the game as much as the reality [86].

Conflict of interest and potential sources of bias would need to be managed [28, 75]; for example if commercial interests are involved when professional reviewers create the reviews [21, 38], or when written by the developers as a way of marketing a game [28, 29]. Reviews sites often host and distribute the same games that are being reviewed [68]. Blind reviewing is typically used for peer review [103] while review sites can instead disclose detailed reviewer metadata [95]. Ecosystems where issues identified in the review can be verified or discussed are less likely to allow bias to propagate [26].

- **Quality control**: Reviews are assumed to be based on actual player experience, with some reviews sites able to validate that the reviewer does at least own a copy of the game [60], or has sufficient play experience [75]. However, it may be possible for reviews to be created with different levels (including zero) of play time [4, 94], or be created based on other reviews [33, 23]. Review credibility can be established by providing information about the reviewer [8], such as their play and review history, motivation for creating the review, or experience with game design [86]. Reviews created by professionals, e.g., journalists are structured, rigorous and use appropriate terminology [58, 55, 76], while amateur reviews are created spontaneously with no external incentives [47]. Reviewer interactions within a community can have a detectable influence on review contents [86].

  Review sites may prompt for particular information implying that unprompted topics that occur frequently represent an intrinsic property of the experience being reviewed [65]. Nostalgia leads to positive reviews created long after game release [74]. Rigor is introduced by collecting and analyzing data according to frameworks, scales and measures, defined processes and models with standardized questions [22]. These are then analyzed and reported using descriptive statistics and hypothesis testing [27].
- **Effort involved**: Review sites can simplify the creation of reviews by allowing short comments [21, 80] or even numerical ratings [34, 8] as a form of review to quickly capture a holistic view of the game. Online reviews are created and hosted on sites designed to support creation of reviews [57, 64]. Negative reviews are often short but written earlier [94], with positive reviews requiring more effort to describe the value in the experience, or to refute previous reviews [53]. More complex processes exist that involve recording and reviewing game play over many hours and where analysis of this material drawn out through interviews and discussion with others [31, 21, 23]. Reviews produced as published case studies follow formal research processes such as interviews and focus groups, expert evaluations, surveys, case studies, experiments, use of models and frameworks, pre- and post-tests, heuristic evaluations or logs [21, 22, 23] with tools to support these processes [2]. In contrast most casual reviews never mention the review process [59]. Typically a review is created by a single author [44] although a review ecosystem is created by a community [61].
- **Stage**: Most reviews are created some time after playing the game, particularly after the player is invested in the experience [54]. There is value in creating the review while playing [23] or reviewing while re-watching recordings of the play experience [31]. Experts typically create reviews soon after a game release, while amateurs can still be creating reviews years later [74]. Priming by positive/negative reviews before play has an impact on later reviews created [33]. In a design context, reviews occur at stages of design (e.g., preliminary, working drawings, schematic) [26] or during testing [71] so do not require a finished product before a review can be completed. This theme suggests that context should be considered in an *experiential review* ecosystem by recording the background of the participants [81, 8] and the structure of the community that is established. Peer review systems include a stage involving revision of the product after the review is received [91].

D. Ecosystem management

Collecting reviews involves creating, collating and managing these assets on an ongoing basis. The interactions between multiple components (the games being reviewed, the people doing the reviewing, and the environment that hosts the reviews) is similar to an ecosystem resulting from the interactions of organisms and their environment. Only a few of the sources [21, 22] explicitly identify this overarching environment and the processes involved in managing this although many of the others implicitly identify ecosystem structures and mechanisms.

1) Structure: The components of the review ecosystem include the groups of stakeholders that are involved in creating, curating and benefiting from the reviews that are produced. Figure 10 enumerates the groups that are identified. The names used for each class of stakeholder represent the terms used in each cited source that interprets their role and function.

Four categories of ecosystem elements are identified. These categories are consistent with social communication theory that identifies: the review writers (communicators), the review users (communicatees), and the review hosts (channels). The fourth category of review modifiers matches the communication category of response; the action taken after reading the review but does also include modifications to the review during any stage before and after publication.

Review writers produce reviews. These are the game players although various special interest groups can also be identified. From a commercial perspective, professional review writers and the game developers have a financial interest in the content of the review. Educators who intend to use the game in class will evaluate its suitability to meet learning outcomes. Academic analysis of particular games results in papers from academic reviewers. A less common source of reviews are those created for quality control where the review is used internally to refine development of the game. The subtle

distinction between game owner (purchaser) and game player as a source of reviews relates both to a form of validation (that the reviewer has actually played the game before writing the review) and a source of bias (the owner has already invested in the game).

Review users gain the most direct benefit from the review ecosystem. These are game consumers for whom the review provides guidance on game choice. Consumers are players viewed from the perspective of purchasing games and consuming reviews. Game designers and developers are also well represented since reviews can determine the success of a game and the insights communicated within the review provide guidance on refining the game. Review insights are valuable as reviewers may have experience with a wider range of games than many game developers [59]. Reviews identify games that can be repurposed for education, although relatively few sources explicitly mention the need to verify that the information provided by a game is accurate [29]. Internal reviews are another form of the review ecosystem that operates within organizations, to the overall benefit of the organization.

The ecosystem extends beyond the consumption of raw reviews. Collections of reviews are used for text mining. Review rating systems provide recommendations or can be used to fit predictive models. Assumptions around the nature of reviews can also be challenged; for example that a review of a game is independent of the player. Each player has a unique background which defines their play experience and has their own personal approach to interacting with the game.

The environment in which reviews exist is the fourth category. Game reviews exist in online game review sites, but are also hosted in publications created for this purpose. Unlike physical publications, online reviews exist in a space without boundaries [75]. These sites may supplement reviews with information such as the reviewer history and reputation [81]. The reviews support their hosting sites by directing purchase decisions for the products reviewed, but can add value by providing the basis for a social community that provides trusted, word-of-mouth recommendations. Other forms of review, such as academic papers reporting case studies, exist in paper repositories and databases.

2) Incentives: Effort is required to produce quality reviews [100]. Games utilize a wide range of incentive mechanisms, both within the game to encourage the player to follow rules and achieve goals and externally to incentivise the purchase of the game and game related content. Review ecosystems, particularly those that support access to games and to game play, employ incentives to encourage participation and contributions.

The incentive mechanisms reported are relatively mundane. For academic papers the incentive mechanisms are inherited from those for publishing research [25]. Peer review communities share both the effort and benefits of reviewing [90]. Such academic peer review systems contain multiple roles and many feedback loops [98]. There is little incentive to standardize the *literature review* process [22] (while noting that the papers themselves do follow publisher guidelines). New *literature review*s are only created once the field has developed sufficiently to justify an update [2]. Researchers also create games for particular purposes [23] which provides an incentive for producing reviews in the form of case studies. Free metadata useful for research that is provided through review ecosystems would be costly to produce via other mechanisms [67]. Analysis of existing review systems identifies structures that can be formalized to guide future review writers [63].

Paid experts are more prolific in producing reviews [74]. Extrinsic motivation applies when designated experts are commissioned to produce reviews [28, 58, 51, 8] or where review processes are managed within a team [26]. Payment for reviews is an explicit incentive mechanism [5] but is reflected in that longer reviews are created. Similarly, those receiving professional benefits from reviews (e.g., educators choosing appropriate tools to support their work) are implicitly encouraged to utilize sources of informative reviews and to support such a system [24]. Some groups of players are not able to directly produce their own reviews (e.g., young children) and so their perspective needs to be captured indirectly by others who observe or interpret [23]. Pandemics produce motivation in the form of need to play combined with additional free time to provide an opportunity to create reviews [72].

Community game review sites are a form of emergent ecosystem [76], each with their own style and conventions for reviews. Emergent systems [104] benefit from large numbers of contributors and low barriers to entry as this allows messages from individuals to reach a wide audience [72]. Comment sharing facilities are provided with no further incentive mechanism [5] beyond providing a way to share word-of-mouth opinions [32, 86] or as a way to influence game developers [5] offers the benefit of addressing issues affecting enjoyment of the game. Social standing is enhanced by reviewing popular games [5, 60]. Community ranking is an incentive as evidenced by greater levels of reviewer engagement with small independent game developers [5]. Commenting directly on an experience ensures that the opinions expressed are directly related to that experience [80]. Anonymous reviews remove constraints on what can be expressed which is both a pro and a con [53, 103]. Conversely the number of friends listed for an identified reviewer [8] and privacy of play history [95] affects the perception of the review . Participating in a review ecosystem changes the way players assess games and develops increasing sophistication in reasoning about them [48]. Setting an expectation that reviews can be short [21] produces a greater number and variety of reviews that can be distilled to reveal the wisdom of the crowd. Scarcity mechanisms (limit of one review per game) provide incentives for quality reviews [5]. Recommendation systems need to be seeded with some user created reviews [61] requiring a contribution before benefiting from the ecosystem.

Trust, accuracy and consensus increases with the number of reviews [57, 92, 99] and is eroded by fake reviews [38, 86] and commercial conflicts of interest [85]. A helpfulness rating assigned to reviews is a meta-review, where the incentive to provide these would be linked to how these support purchasing decisions. The calculations used to produce such scores need to be transparent to avoid the perception of bias [85]. Scoring reviews through a helpfulness rating [3] helps increase the ranking and visibility of the review [43, 81] but can discrim-

Ecosystem elements	Stakeholder group	Purpose	Identified in
Review writers	Researchers / Academics	Evaluating games and reasoning about their properties	[25, 31, 21, 30, 99]
	Game players / Users	Sharing opinions	[3, 4, 31, 21, 5, 33, 22, 23, 34, 39, 40, 41, 44, 45, 46, 48, 49, 52, 54, 55, 56, 57, 73, 60, 68, 74, 70, 84]
	Game Owners	Rating of their property	[5, 30]
	Professional / Export review writers	Make recommendations and critical assessment	[4, 21, 33, 23, 28, 36, 58, 48, 52, 55, 74, 88]
	Game Creators / Developers	Providing information on their product	[27]
	Reviewers / Testers	Performing quality control, contributing to game development	[26, 28, 37, 47, 49, 51, 71, 59, 2, 8, 86]
	Educators	Reporting educational content	[28]
	Students	Creating reviews while learning	[35]
Review users	Educators	Selecting games for use in class	[25, 22, 27, 28, 29]
	Students	Selecting games to support education	[22, 27]
	Domain experts	Validating material presented	[29]
	Researchers / Academics	Using reviews as a source of data	[40, 79, 68, 76]
	Customers / Consumers	Making purchase decisions through word of mouth recommendations, of products from review sites	[3, 32, 4, 5, 30, 28, 39, 43, 58, 51, 52, 57, 72, 66, 38, 74, 70, 76, 81, 84]
	Game developers / producers / designers / writers	Feedback on games, to support refinement	[3, 4, 31, 5, 33, 27, 26, 28, 36, 37, 41, 42, 58, 46, 48, 49, 51, 52, 56, 79, 62, 72, 73, 60, 68, 74, 70, 76, 59, 86, 97]
	Owner / Publisher (of the game) / Marketer / Editor	Ensuring product is of an appropriate standard, and commercially successful	[26, 46, 51, 52, 57, 72, 66, 38, 93, 99, 90, 101]
	Regulators	Third parties who need insight into game properties	[56]
Review modifiers	Raters of reviews	Identify most relevant reviews	[3]
	Funders and editors	Determine which reviews are created and published (in academic journals)	[2]
	Game	Review is an interpretation of play, in an interactive game	[31]
Review hosts	Academic paper repository	Dissemination of academic research	[25, 23, 2]
	Book / Magazines / Publishers (of reviews)	Curated collection of structured reviews	[28, 51]
	Commercial site selling games	Reviews support purchasing decisions	[3, 32, 5, 30, 72]
	Commercial site hosting reviews	Reviews and social ecosystem drive traffic to site	[4, 38, 75, 92, 8]

Fig. 10. Structure: components of a review ecosystem

inate against both unpopular and new products that have few reviews [81]. Helpfulness ratings can degenerate into being measures of consensus rather than a quality rating for a review [4]. Early reviews can shape the tone of later ones [33] hence there is an incentive to ensure accurate (or positive) early feedback.

In cases where developers provide information about their own games, there is an incentive to shape perceptions of the games through this [27]. Developers benefit from a review ecosystem by gaining an understanding of reasoning processes used by players, and insights into the strengths and weakness of other games [36, 71, 86]. The ecosystem reveals a consensus [39] that can be considered to represent an objective viewpoint [41]. The commercial benefits of a review ecosystem extend beyond just promoting sales and extend to community building within many of the online review sites being hosted on the same platforms that sell the games [58].

3) Value: In terms of game theory different stakeholders are incentivised to produce reviews because the strategies leading to review creation have a higher payoff than other strategies. This payoff, the difference between reward and cost, can be financial [5, 23, 102] but is mostly provided as other forms of benefit.

Figure 11 summarizes the various rewards and costs that have been identified in review ecosystems. Rewards concentrate on the benefits of creating reviews, as opposed to additional value being associated with the products reviewed. Review authors receive direct benefits that can be financial, particularly for professional or expert reviewers, or altruistic in that reviews increase the quality of the games they play, or intangible such as higher standing in the gaming community when quality ratings are applied to reviews. Despite these rewards, it is possible that reviewers are intrinsically motivated and would create reviews anyway [47, 101]. Social media effectively provides unlimited free reviews [80]. This is balanced against the downsides: writing reviews requires effort. In some cases, there is particular disincentive (perceived lack of novelty) for writing reviews for already reviewed products, both as game reviews but also academic studies [27], despite the benefits that reproducibility would provide.

Other stakeholders are motivated to manipulate incentives in a review ecosystem. Developers benefit from the feedback provided to the development process. Reviews identify good design practices enabling better quality products. They help connect products with the people who can best utilize them. The trade-off is the effort involved in monitoring a continuous stream of reviews resulting from a thriving ecosystem, and the risk that reviews may be subverted to promote other agendas (e.g., review bombing [4]). The gaming community uses the review ecosystem to spend money efficiently but also to identify experiences that add value to the participant. The number of reviews represent public exposure that is often as significant to publishers as the review content [55].

A review ecosystem functions as a collaborative social network [26]. The costs to the gaming community is the effort involved in moderating reviews, usually through review rating, but also the risk that early poor reviews can influence the tone of later reviews [33] which can introduce bias to the community. Educators and trainers receive a similar benefit to developers when the relevant experiences can be identified and used for their intended purpose or adapted. Reviews are a way to measure the quality of the educational experience. Quality assessment is also the target of reviews in the form of academic case studies. The financial impact of reviews provides both rewards and costs when they influence product sales positively or negatively.

The academic community represents an environment with a long established review ecosystem (in the form of published papers). While full details of the incentive system used in academic publishing is beyond the scope of the sources reviewed the principles involved are worth considering when developing any review ecosystem.

4) Quality: Reviews cover a wide range of topics confounding comparison of specific elements of a game [47, 68, 8]. A measure to compare reviews or assess qualities of a review is required to prevent the ecosystem being saturated with large numbers of poor quality reviews. The goal of a review ecosystem should be to link user attitudes through the reviews to the issue causing the attitudes [70]. The different approaches to assessing this quality in reviews are listed in Figure 12. Care is taken to focus on comparison mechanisms for *experiential reviews*, with many sources also discussing quality measures for the game being reviewed [75]. These overlap with the quality of the review being linked to the way in which it describes particular game attributes such as challenge, conflict, interaction, immersion, narrative and game rules and goals. Other measures of review quality relate to the structure of the review itself, such as the word count, readability and sentiments expressed. Reviews need to describe the same version of an experience when comparing qualities [52] and avoid introducing external factors such as the reputation of the publisher [54].

Approaches to identifying review quality range from manual approaches, where ratings are assigned by the users of the platform hosting the reviews, to automated strategies based on forms of text analysis. Criteria, motivation, culture and standards differ between groups of players which complicates the use of numerical scores for comparisons [40, 47, 51, 56, 74, 82, 85]. Aggregation encourages homogeneity and can disadvantage novel products [99]. Automated strategies identify large numbers of potential features that can exist in a review, and identify a relevant subset of these features by correlating their presence to manually assigned quality measures [49]. Trends and insights from the most highly rated reviews efficiently summarize larger sets of reviews and provide value to those utilizing the review ecosystem [81]. The diversity in the metrics used (despite some commonalities) indicates that an ideal quality measure for a review ecosystem has not yet been established.

5) Environment: A review ecosystem exists in a particular environment. Reviews flourish in game distribution platforms which also provide the opportunity to comment or review individual products [33] and can expose play habits as part of the review [95]. Examples of these include Steam [3, 5, 36, 39, 43, 45, 49, 52, 53, 54, 56, 62, 72, 65, 64, 66, 67, 60, 68, 77, 81, 82, 84, 86, 93, 94, 95], Apple App Store

Context	Reward	Cost
Reviewer	Review scoring (ranking, helpfulness rating) [4]. Recognition as a reviewer [3], social standing [5], altruism [53]. An opportunity to express yourself [54]. Creating better game play [31, 30, 65, 86]. Payment [5, 23].	Effort (time and resources) [3, 5, 26, 67]. Replicated reviews reduce reward [27, 2]. Scores as rewards incentivize subverting these mechanisms with biased reviews [43, 48], adding cost of screening and verifying reviews [64, 85].
Product development	A standard for evaluating new products [24]. Identify best practices in design [24, 30, 39, 81]. Provide relevant and specific information to developers [27, 37, 40, 52, 60], and to identify the cause of issues [62]. Problems fixed in early reviews cost less [26]. Ensure products are used for their intended purpose [29].	Review bombing is a risk [4, 82]. Large numbers of reviews become time consuming to monitor and extract information from [5, 52]. Emotional elements need to be removed to find objective recommendations [74].
Gaming community	The gaming experience starts with finding and assessing games via reviews (play is only part of the experience) [48]. Communities for social games overlap with review communities [72]. Value for money when purchasing games [3, 72]. Protect against low quality products [41]. Trusted, and positive reviews have greater value [32, 92], provide insight into products [60]. Reviews as a form of community collaboration [26, 8], with debate via review increasing the value [57]. Online reviews are available at any time [75]. Review ecosystems ensure issues covered represent the wider community [42].	Effort involved in rating reviews [3, 86]. Ratings are required to identify relevant reviews [51, 2]. Negative reviews influence later reviews [33], fake reviews erode trust [64]. Community values differ requiring review standards adapt when sharing between communities [51]. Expert curation may be required [74, 76]. Negative reviews make existing players appear incompetent [95].
Educational and serious game community	Identify applications to support training [22, 27, 29], reducing cost of ensuring fit-for-purpose [65]. Measure of educational impact [27]. Improved learning [97, 90]. Community participation [90].	Presenting information accurately can require expert review [29], or personal experience with the product [67]. Poor quality submissions create extra effort [97].
Commercial interests	Positive (and fake [38]) reviews drive purchases and provide commercial reward [32, 34, 58, 55, 72, 92], including as word-of-mouth recommendations [57, 75] and for new products without history [71]. Reviews provide free support for products [34], including details of platform specific features for platform spanning games [56]. Review sites can sell advertising [58], support product sales [57] and seed review ecosystems [60, 8].	Negative reviews have financial costs [32]. Cost of creating a review site, including costs of paid reviewers [76].
Academic research	Reviews can be academic papers [25]. The research value of review ecosystems increases with the number of reviews [73]. Reviews are an alternative to evaluating a product directly [73]. Competition encourages innovation [98]. Reviewer recognition and financial rewards [100, 101, 102].	Reviews are not created to support research so not directly useful in their original form [47]. Very large qualitative data sets can be a challenge [81]. Competition produces bias [98]. Effort required [101].

Fig. 11. Value, in terms of reward and cost associated with a review ecosystem

Metric	How it is measured
Quality	Based on criteria such as: details of evaluation method, and features assessed [24], standard of writing [58].
Quantity	Subjective variations in individual reviews are reduced by aggregating large numbers of reviews [57, 69, 81, 86].
Helpfulness	User ratings of reviews, also fitted model based on review similarity, structure, readability, and text content features [3, 43, 4].
Taxonomy fit [21]	Validating taxonomy of reviews [6], including features of: adaptation, assessment, challenge, conflict, control, fantasy, interaction, rules and goals.
Scores	Using review measures [98], distributions and histograms [5, 60], weighted aggregations [48, 71], probability estimation [101].
Bias	Correlations in ratings between reviews [33] identifies issues, e.g., fake reviews [64, 2].
Sales	Professional reviews measure product and affect sales, consumer reviews can be caused by sales [55].
Validity	Instruments (reviews) should have: applicability, utility, validity and reliability [22], provided in good faith by players [80] or experts [8].
Predictive ability	Reviews must be able to predict: user satisfaction [30], emotion and engagement [35].
Reputation	Review is trusted in proportion to perceived agreement with previous reviews [34, 61, 86].
Feature extraction	Reviews are suited to feature extraction (e.g., natural language processing [42, 78, 79, 89, 94]) to extract: advantages, comparisons [36], summaries [39], game specific information [67], sentiment [93], topics [84] or keywords [83].
Ranking	The relative ranking of two games can be established using reviews [37, 59].
Trends	Rather than ranking, metrics identify trends associated with particular games [41, 72], clusters of reviews [77] or review style [76].

Fig. 12. Quality measures for *experiential reviews*

[32, 89], Google Play Store [41, 44, 56, 79, 73, 89, 96], Amazon [30, 35, 37, 57, 85] and GameStop [37, 42, 46]. Platforms that support reviews without selling games include Metacritic [4, 37, 48, 55, 69, 74, 70, 83, 88], which aggregates reviews, the video game database VideoGameGeek [21], IGN [37, 42, 46, 59], GameSpot [29, 42, 46, 61, 59, 63, 75], and PC Gamer [29], which are game news portals, and the serious games portal [29]. Reviews in the form of videos are mentioned less frequently but do occur in dedicated channels on sites such as Youtube [34]. Reviews are also sometimes hosted on blogs and social media sites [57] and in the form of comments, for example to game play videos on Youtube [80].

Steam is a popular contemporary option for review analysis because it is a successful review ecosystem and also because it is possible to download or scrape large numbers of reviews from this site. Its size also ensures that even speciality areas are well represented, such as VR experiences [40, 47] or reviews in different languages [50]. Other sites hosting VR experiences and reviews include Viveport and the Oculus/Meta store [47, 78].

Academic case studies as a form of review are hosted on publisher and paper indexing sites, such as the ACM digital library, IEEE Explore, ISI Web of Science, SCOPUS, Springer Link, Wiley Online, and Google Scholar [24, 22, 27, 23, 8]. Review registries and indexing sites are essential in finding relevant reviews [2]. Unlike game distribution ecosystems, these are often behind paywalls and are not accessible to the general public or many professions such as classroom teachers. Grey literature is also a relevant source of valid review information [24] as case studies may also be reported by industry or government sources.

Game reviews were originally published in game focused magazines [34, 58], such as Computer Gaming World, Computer Games, PC Gamer, Soft World, Game World [51] and MikroBitti [76], and on web portals [58, 51]. Game reviews for games in specific categories such as serious and educational games may be published as collections in books [28, 91, 90]. Novel environments include a 3D review environment [26] that is well suited to the review of 3D designs.

6) Viability: The length of time that a review ecosystem has existed (or will continue to exist) is an indicator of its viability. While the sources consulted rarely discuss the viability of review ecosystems, they do frequently describe these systems in terms that refer to a range of indicators of viability. The major classes of review ecosystem and their viability indicators are:

- **Published academic case studies** [25, 24, 22, 27, 99]: The subtleties of the academic publishing environment are beyond the scope of this review although it can be regarded as one of the longest-lived systems with established quality control processes and dedicated, incentivized contributors. Only particular topics (e.g., usability evaluation [23]) vary in popularity over time.
- **Game distribution platforms**: (e.g., Steam, Apple App Store, Google Play Store, Oculus/Meta Store and Amazon) have existed without interruption since their creation and reviews are available for most of their lifespan [43, 45, 50, 78, 60, 68, 81, 86] making age a predictor of further longevity. While these platforms focus on distribution they add significant value by also hosting reviews and integrating these into their business [94]. This feedback loop ensures all stakeholders benefit from the ecosystem [5, 33, 56, 57]. It also allows for quality control by ensuring reviewers have purchased and played the game [62]. These platforms use additional viability indicators: popularity [78, 65], number of products [39, 79, 66, 60, 68, 81, 82, 84, 85, 89, 96, 93, 95], market share [68, 81, 95], turnover [96, 95], number of products reviewed [36, 61], number of regular active users [39, 66, 60, 68, 81, 82, 84, 86, 93, 95], contributions per

user [86], and number of reviews [36, 54, 66, 74, 61, 85], with accumulation of information increasing the value of the ecosystem and range of uses for the reviews [72, 84]. Viability is adversely affected when applications are removed from the platform, which may affect their associated reviews [96].

- **Review platforms**: (e.g., Metacritic, VideoGameGeek, GameStop, GameSpot, IGN) achieve longevity by sourcing reviews from both amateurs and professionals [4, 69]. Additional viability indicators include: amount of traffic [46, 75], reputation [46, 55], amount and relevance of content [46, 55], and diversity of stakeholders [46]. Such platforms do need to adapt to changes in reviewing trends to stay relevant [21, 37] and avoid risks associated with poor quality or fake reviews [48]. Perceived commercial conflicts of interest can also affect the value of the reviews [8]. The serious games portal [29] is relatively new and represents a good case study into establishing a review ecosystem.
- **Game journalism**: Media such as magazines and websites with professional reviewers depend on advertising income and become less viable when other platforms become more popular [58, 51]. The acceptance of games, and game reviews, across society is linked to reviews spreading from specialist magazines to general purpose media [76].
- **Social media**: Such platforms tend to facilitate comments rather than formal reviews and so indicate viability through properties related to the health of the comment stream (e.g., number of commenters [80]).
- **Professional review**: Industry processes for quality control include reviews [26], and are classified as stable in that these are established professional processes.

Custom review processes [31], or reviews assembled into books [28] are one-off systems for which the concept of viability as an ecosystem is ill-defined. These are more viable when using open access allowing them to be easily copied [90].

7) Challenges: The previous sections have focused on solutions; strategies and elements that produce viable review ecosystems. This section focuses on the challenges; the problems that still need to be resolved in order to build future review ecosystems.

Consumer sites have demonstrated that it is possible for non-specialist reviewers to produce reviews that add value to particular communities. The incentives used (section III-D2) ensure that producing reviews incurs almost zero cost [32] although storing and providing access to review information does require costly expertise [67]. A key challenge in those environments [32] is to verify the motivation of reviewers [4, 55] to ensure that the reviews remain credible and are not manipulated [38, 98]. Commercial sites may screen reviews to avoid upsetting advertisers [51] while professional reviewers can experience pressure to score consistently with other reviews or sales data [55, 86]. Games are released in different versions and with updates and reviews need to indicate clearly which versions are described [37] so that reviews are comparable [67]. The site focus can be a challenge; for example a game focused site may host VR chat applications but not facilitate reviews appropriate to these applications [84].

Commercial game review sites are satisfied with each review representing the subjective opinion of a single player [58] unlike case study reviews where properties such as quality or usability are aggregated measures generated by sampling significant numbers of players [24]. Having large numbers of people contributing to a single review is challenging but offers the opportunity to create robust, reproducible and relevant reviews.

Large numbers of reviews need to be ranked so that only the most relevant are presented to readers [43]. The correct ranking of a review may depend on the contents of the review, the preferences of an individual reader and the evolving needs of the community [58]. Reviews from the same author are easier to compare, but only professional reviewers tend to consistently produce multiple reviews [74].

Reviews consist of several fields, including a numerical rating for the product as well as the text of the review justifying this score. Review ratings provide a single measure that scores the review. This rating is coarse and introduces the challenge of identifying which property of the review (if any) is the basis for the rating [4]. Some sites might only provide a binary positive/negative which excludes even a neutral rating [47]. Ratings reflect unconscious bias and lived experience [53, 60]. Review text tends to consider each game in isolation and may fail to provide an analytical description of the game play [59] or even a structured comparison listing pros and cons [85]. Community review standards adapt to the current state of the games industry [58] and differ according to cultural values [51]. Further complicating matters, new review ratings could be interpreted as agreement with previous review ratings [86]. Identifying which features of a review are relevant is still an open problem.

Several review analysis strategies decompose review text into features which are then analyzed individually. Different contexts may then utilize only some of these features [4, 82], providing the challenge of adapting reviews for different purposes such as relevant issues to each player and specific product information for vendors [46, 66]. Ideally reviews would be structured with defined sections that support analysis [36]. Formal review processes provide specific documentation [26] that adheres to defined standards. The diversity of games requires that new metrics be invented to report on particular properties of an innovative design [23, 71]. An alternative hypothesis [21] is that reviews are holistic and individual elements should not be considered out of context. This has some support in that a common language for reviews has yet to be established (see section III-B2). The challenge is to devise a review analysis process that does not start with a decomposition stage.

Consistency in reviews, particularly where measures need to be compared across reviews, requires a systematic process to evaluation [22]. The evaluation model needs to be specified in the review, and the evaluation carried out correctly [27, 97]. Unintuitively, review quality improves when the review is costly to the reviewer (e.g., requires an investment of effort) [101]. This is a challenge for educational and serious games as

there are logistical challenges to conducting evaluations with students in a classroom and while being accommodated within an already complex learning environment. Review quality is preferred over quantity within high-involvement communities [8]. The quality of the game itself is not sufficient either; reviews of serious games need to report on how well they meet educational goals as well [28]. Systematic review processes are not currently applied in generating game reviews [8].

A trend in reviews is to encourage longer detailed reviews since these are identified as being more useful [72]. Extreme cases [31] that involve 20 hours of game play, curation of video recordings and interviews provide significant insights but with concomitant investment of resources. The challenge is to maximize value of the review while minimizing the effort required to produce that review, for example, by focusing only on aspects that would have the greatest impact [2].

IV. Results

The detailed analysis leading to these results is presented in section III. This analysis links the sources reviewed to the categories identified and recommendations made in this section.

A. Purpose

Review ecosystems exist for a range of purposes. The goal of a new review ecosystem can be: gaining understanding, sharing insights, collating information, conducting assessment and promoting products. The purpose of the review then adapts to this goal by either encouraging informal reporting by participants, following set processes with groups of reviewers, or applying consistent and rigorous evaluations across the entire ecosystem. The information presented in the review may be intended for later analysis, or designed to be used for a preset purpose. Opportunities exist to exploit review ecosystems as they scale, where synergies may result from multiple reviewers contributing to a common review, reviews covering multiple games, or by aggregating multiple reviews.

B. Form of the review

The goal is to develop insight into the mechanisms used to create and manage review ecosystems. This starts by defining the properties of individual reviews: how they are presented, what information they contain and what they provide.

1) Format: Reviews are usually written documents that can exist in several forms. There are few examples of other media formats. A new review ecosystem would specify the form and format for reviews. Free form text is the most flexible but complicates analysis. Fixed format documents with defined sections ensure that the review covers particular topics. Academic case studies include details of the process used while reviewing. Opportunities exist to exploit other formats and media; from sets of numerical ratings to comment streams, images and video, interviews, streams and recordings of the actual game play, and as reviews embedded within virtual environments.

2) Template: A review template specifies particular elements of a review that are common to all reviews within an ecosystem. Development of a new review ecosystem is an opportunity to establish a review template that ensures relevant information is included in each review. Minimum requirements are product metadata to describe the product being reviewed and the review content with product description, and pros and cons. Other template fields are: reviewer details, product specific properties (for example, games would include: narrative, challenge, gameplay), quality indicators, and messages to particular groups of readers (e.g., developers). Specialist template topics describe educational content, assessment mechanisms, and the review process. Templates for reviews of reviews would include review metadata or features extracted from the reviews.

3) Focus: The focus of the review is an opportunity to shape the community that will form around the review ecosystem. The focus of the review can be to: inform others, contribute to the community, show status, reflect on game designs, influence purchases, promote products, provide feedback to developers, report problems, evaluate educational experiences, or categorize games.

4) Field: Most reviews analyzed relate to games, with a smaller subset relating to virtual and augmented reality. Review ecosystems consist of collections of reviews that provide insight into the domain of the reviews while having secondary relevance to other overlapping domains. New review ecosystems should select the class of product to review when building a review ecosystem. While games are well represented due to the focus of this *experiential review*, sub-fields based on platform (mobile, desktop) or category of game (multiplayer, serious, simulation, therapy) support review stakeholders with a particular interest. Areas such as virtual reality, augmented reality, and mobile applications with their own sub-fields, can exist independently or within other review ecosystems. Some studies specialize further to individual dimensions of games such as play experience, narrative or addiction, or to the intersection of games and other fields (e.g., health, journalism). Opportunities exist to identify further fields, or explore the relevance to other fields of the reviews that exist in established review ecosystems.

C. Review utilization

The next step in understanding the motivation that sustains a review ecosystem is to ask who uses reviews, what they are used for and how they are used.

1) Target audience: The audience for a review ecosystem extends beyond just the readers of the reviews. A new ecosystem can be strategic in targeting particular audiences. The audience of interactive application reviews can be one or more of: designers and developers if focused on reasoning about, and improving, games; customers and publishers when marketing and selling games; and reviewers and players when discussing games and the play experience. Game reviews have other audiences: teachers and students using games to support education, and researchers investigating reviews and understanding games through reviews. The audience can

extend to include other specialists who want to access games identified through reviews, e.g., health professionals who can use games for therapies.

2) Usage: Reviews will find use within their intended focus areas if the review ecosystem ensures they are useful. This requires strategies that ensure they are trustworthy and represent the authentic experience of the author. Useful reviews need to reveal information (e.g., insights to guide developers) and be available for analysis (e.g., by supplying many reviews, or by structuring them to simplify information extraction). Reviews support player communities by describing game play strategies and offering support for dealing with problems. It must be possible to identify the relevant and useful parts of a review. Opportunities exist for review ecosystems to incorporate elements that present and refine insights based on contributed reviews, and provide this as a service to stakeholders.

3) Education: Education is a strong theme in a number of the sources identified. When deciding on the relevance to education of the review ecosystem, the design choices include: rating and measuring educational value, identifying and adapting experiences for use in education, and/or assessing and integrating educational outcomes through creating reviews. EduXR review ecosystems represent one opportunity to systematically manage these processes and allow the educational value of different experiences to be reported and compared.

4) Mechanics: A review ecosystem supports the creation of reviews that are consistent with the goals of the system. The processes that achieve this include: identifying the source of information (one game or many per review; whether reporting on an experience, assessing a product, or refining a design; determining the background, professional experience and sources of bias of the reviewer), enforcing review process rigor (credibility of the reviewer, experience with gaming and the game, review structures and standards, levels of objective versus subjective content), providing efficient review creation tools (ratings, short comments, or long reviews; tools for analysis as well as reporting), and defining when the review is performed (aggregation of other reviews before playing, during play, immediately after play, after significant amounts of play, long after play based on nostalgia, after watching recordings of others playing). Opportunities to innovate with these mechanisms include linking annotated evidence from the game play experience to relevant sections of the review. This would add value when showing how to repurpose games for therapies or other purposes.

D. Ecosystem management

Review ecosystems create, collate and manage reviews on an ongoing basis. The interactions between multiple components (the games being reviewed, the people doing the reviewing, and the environment that hosts the reviews) is similar to an ecosystem resulting from the interactions of organisms and their environment. Only a few sources [21, 22] explicitly reason about collections of reviews.

1) Structure: The four categories of ecosystem elements are: the review writers (communicators), the review users (communicatees), the review hosts (channels) and the review modifiers. The latter involves the actions taken after reading the review and other modifications before and after publication. Of the four ecosystem elements, choices can be made with respect to: review writers and their purpose (rating, recommending, repurposing, reasoning or refining the game), the review readers and their goals (decision making, analyzing experiences to identify the effects of design decisions, measuring value), review modifiers (translating reviews so they can be used for additional purposes), and the review medium (paper, online with restricted access, online and open) with its associated hosting environment (once-off specialist repository, curated collections, review site with associated market, specialist review ecosystem). The review modifiers represent a prominent area of recent research focused on extracting insight from the readily available data consisting of large collections of reviews.

2) Incentives: Review ecosystems use incentives to encourage participation. The incentive mechanisms used in review ecosystems can be significantly enhanced using innovative practices employed in areas such as gamification and persuasive technology [105, 106, 107]. Traditional incentive mechanisms employed in review ecosystems to encourage participation (review creation, rating of reviews and reviewers, community engagement) include: financial incentives, status within a community, career progression, self-interest including promotion and marketing products, ecosystem related benefits such as collaboration and cooperation, emergent ecosystem benefits such as wisdom of crowds, free stuff where reviews are sources of data for research, scarcity as an incentive, and opportunities for personal growth). Disincentives that need to be managed are bias that erodes trust and adverse community interactions.

3) Value: Stakeholders produce reviews because strategies leading to review creation have a higher payoff than other strategies. A review ecosystem maximizes the value of rewards and minimizes the associated costs. Potential rewards include: intrinsic personal rewards (status, altruism, improved play experiences), extrinsic personal rewards (money, improvements in quality of game experiences, ability to identify relevant games), commercial benefits (improved development processes, higher product quality, validated targets for evaluating products, increased sales with less marketing effort), community rewards (support from other community members, emergent benefits of aggregated reviews) and specialist rewards (can identify and adapt games for specialist purposes, can share evaluation tools). Costs that can arise include: overheads associated with producing reviews (financial cost), overheads associated with managing the ecosystem (effort of curating reviews, hosting costs), community management (managing quality and accuracy, setting community standards), and the effort associated with utilizing reviews (accessing large sets of reviews, extracting insights from free-form text). An opportunity for an additional reward is to use reviews to observe behaviour within gaming communities without adding additional forms of data collection that might disturb the system.

4) Quality: Review quality measures direct tho reader's attention to relevant reviews and indicate the value inherent in each review. Measures relate to individual reviews including: intrinsic measurable review properties (quality, taxonomy fit, validity), review meta data (reviewer reputation, sales levels), reviews of reviews (helpfulness) and the ease with which insights are extracted. Quality is measured for collections of reviews using aggregation, statistical measures, correlation, ranking and trend predictions. An opportunity exists to find ways to validate reviews by including evidence of the claims made.

5) Environment: The review platform can be: an online platform (with product sales and reviews, dedicated review portal, other review formats such as video, social media service supporting comments, curated and restricted platform such as academic publishing, special interest group like an online gaming community), or printed media (books, magazines). Beneficial platform services include providing: downloads of reviews for additional analysis, and effective review ranking and search. Review environments could make better use of media modalities, with game play streaming being a form of review, or other platforms (e.g., reviews hosted within a game, or virtual environment). Review platforms that link two different experiences within a single review would facilitate comparisons and ranking.

6) Viability: The length of time that a review ecosystem has existed (or will continue to exist) is an indicator of its viability but other measures exist. When creating a new review ecosystem viability is an indicator of the longevity of a self-sustaining system as are measures such as size (e.g., number of reviews, number of users), levels of engagement (e.g., rate of reviewing, rate of usage), or measurable properties indirectly related to the reviews such as product sales. Approaches to achieve viable ecosystems include: combining product sales with reviews so the feedback loop ensures reviews respond to but also influence products, paid professional reviewers (e.g., review platforms, academic research) to ensure review quality and relevance, and integrating with social media to focus on user engagement. Specialized communities require continuous injection of resources to remain viable (e.g., advertising revenue for journalistic media, professional practices for quality reviews during development). Opportunities exist for platforms that facilitate comparison and analysis of reviews during and immediately after their creation.

7) Challenges: New review ecosystems need to overcome challenges such as: cost (of creating reviews, of curating them, of validating them), knowing information about the reviewers (amateur/professional, motivation, experience, reputation), review process and structure (one contributor per review or many, formal or ad hoc reviewing processes, defined topics or free text, numerical rankings and/or qualitative opinions, one game per review or many, long detailed reviews or streams of short comments), and utilization (rankings for reviews, sharing, analysis processes, reuse and repurposing). Some of these combinations represent new opportunities such as challenging the notion of a review as a single document produced by a single author representing a single instant of the experience. For example, there are proposals for *literature reviews* which receive continuous updates from multiple contributors rather than generating duplicates with minor refinements [19, 108, 109].

V. Discussion

The **first goal** of this review is to identify and describe trends related to current practices in preparing, presenting and maintaining a set of *experiential reviews* within an *experiential review* ecosystem. The analysis (section III) and results (section IV) extract and summarize the strategies used within known ecosystems within the broad headings of form, utility and ecosystem. The *form* of an *experiential review* determines what information is included and how it is presented (section IV-B). This then leads into considering the *utility* of an *experiential review* and the value that it needs to provide (section IV-C). The community that develops around an *experiential review ecosystem* provides the value for all participants, and completes the feedback loop of producing and consuming *experiential reviews* that ensures the ongoing stability of the system (section IV-D).

The **second goal** is to present practices that can be used to establish and enhance the *experiential review* ecosystem for eduXR experiences. This outcome is summarized in Figure 13.

The following sections discusses trends identified through the relationships between each topic and present the opportunities to establish new ecosystems that have been identified through this synthesis.

A. Synthesis

1) Form: Figure 6 identifies the categories of information present in *experiential reviews*. Review ecosystems for eduXR would extend these to identify and include information that captures the intersection of education and XR. Additional information would expand on the quality of the experience, the social community, the development and commercial opportunities, and diverse specialist needs such as education and therapy. The amount of time spent playing is a valuable indicator of review quality. Alternative measures are required for eduXR experiences that are of fixed duration, or have a linear narrative that discourages replay, to accommodate the new cohorts of students experiencing them for the first time. An XR experience can include game play but can also be very different in how it makes use of the reality spanning medium and the value that it provides to participants.

Despite the growing popularity of game streaming services as a form of video review the format of reviews reported are written documents and mostly unstructured content as free form text. Attempts to structure reviews are common but no mechanism has yet been identified to ensure a single standard is adhered to or that such would meet needs beyond those of niche groups. Natural language processing can extract topics from review text and can mine reviews for insights beyond those expected from a fixed review template. Reviews recorded directly in XR would capture the experience directly but would add challenges related to utilizing the review. Regardless of the review format, they need to be indexable to support

searching and comparisons of reviews. Review presentation can be separated from the form used for review creation with opportunities to restructure and reformat, for example, to present a customized overview summary with highlights using multiple media.

2) Utility: Reviews attract a diverse audience but the nature of the reviewer themselves is often overlooked. Information about the reviewer provides additional insights, authenticity and utilizes reputations. Review systems that employ social network mechanics share reviewer details and profiles. Academic *experiential review*s reveal personal author information but also details of the number of users who tested the experience and their demographics. Reviews can be prepared directly by those who use the experience (e.g., expert reviewers, players who write their own reviews) or distilled from reports of others (e.g., user questionnaires). An assumption underlying most review systems that a game player role intersects with the review author role. Recognition of roles leads to opportunities to explicitly include information describing the person behind each part of the review and envisage additional roles. For example, an *experiential review* need not only report on the player's experience but could separate the stages of play (or generating evidence or provocations) from the analysis which could be performed by specialists across several fields as pioneered by [31].

Reviews are distinctive in that they are trusted. While the mechanics of trust are complex, trust is typically achieved through the alignment between the interests of the reviewer and the consumer of the review. Potential for bias is also reduced when there are multiple roles contributing to a single review.

Analysis and data mining identifies patterns present across an entire repository of reviews. Review ecosystems tend to assume that review is used in the way that the author intends it to be. In the context of an eduXR ecosystem we anticipate that aspects of a single experience may be adapted for use across several lessons with different learning outcomes. Different portions of a review may hint at these different opportunities. Review ecosystem utility increases when further insights can be extracted from existing reviews, or if review structures can adapt to increase the value that can be extracted.

3) Ecosystem: Review ecosystems are most prominent in the platforms that host and sell games and use reviews to guide player purchasing decisions. The secondary ecosystem around educational games uses reviews to select, but also validate, the educational value in a game. Academic research, such as case studies, also generates product reviews with added rigour applied to the method and with a focus specific to a field of research. Internal review ecosystems within organizations mirror the structure of other ecosystems with explicit goals for the review process. Creating a review ecosystem starts with defining goals. The ecosystem itself is then structured around the components that write reviews, use reviews, host or communicate reviews, and that modify and extract insights from reviews.

The incentive mechanisms used in review ecosystems are rudimentary compared to what could be achieved. This may be a constraint of the *literature review* methodology since sophisticated incentive and behavioural manipulation strategies employed for commercial benefit are often not discussed publicly. Games already employ a wide range of incentive mechanisms to keep the player engaged that can be extended to gamify behaviour consistent with a stable and valuable review ecosystem. Academic research and publishing is another ecosystem with its own set of incentives (rewards and costs). Regardless of the merits of this system, its stability suggests analogs of the incentives used could be adapted to an eduXR review ecosystem. However, the trust associated with a review ecosystem lies in the honesty of the incentive mechanisms that encourage voluntary contributions, personal growth and community values. Without these, removal of biased reviews requires investment of considerable resources.

Feedback loops are also a form of control system for regulating an ecosystem. Ecosystem mechanics balance the costs of contributing with incentives to ensure a stable ecosystem without opportunities for subversion. Incentives can be explicit rewards or implicit incentives such as social status. A review of reviews is a feedback cycle where review writers are able to identify the value of their work and improve their reports even in the absence of an explicit quality measure. Quality metrics measure both properties of the XR experience but are also used as a filter to identify relevant *experiential review*s. The numerous quality related properties of interactive and educational experiences listed in Figure 6 will be extended as additional eduXR experiences are developed. Quality measures are often proxy-measures of other quantities (e.g., agreement, reputation) and are too coarse to identify specific actions to take in response. Manually assigned scores are subjective, prone to variation between individuals, and can be manipulated by social network manipulation (e.g., memes, review bombing). Automated text analysis trained on manually assigned scores may inherit their bias. Review quality needs to be managed where there are conflicts of interest or sources of bias. A known model that predicts quality can be attacked by procedurally generating reviews with these properties or other adversarial strategies. An *experiential review* is itself a quality measure that trades detail against its flexibility in comparing different experiences. A universal measure of quality may be an aspirational goal but quality measures customized to each stakeholder would provide equivalent value. These would also be used to provide feedback to authors when creating reviews.

B. Case study: eduXR review ecosystem

To illustrate how this review achieves the second goal related to establishing new review ecosystems, the concepts distilled in this paper are applied to the challenge of developing a review ecosystem suited to the specific needs of teachers as described in section I-A. The alternative strategies summarized in Figure 13 are matched to each requirement to provide a high-level design proposal:

Identify relevant experiences: The *review ecosystem* must focus on consistent evaluations whose purpose is know apriori. The *target audience* is teachers and students with opportunities to provide feedback to developers who can enhance experiences to teach particular topics. The *mechanisms* focus on

rigor by requiring objective information, standardized review processes and reporting on the reviewer's credibility. The *incentive* for review creation is that the review ecosystem return value to authors by providing access to reviews created by others. Reputation established and tracked within the review ecosystem also provides *value* for the contributors.

Efficiently accessing information: A written text *format* is efficient to access and search combined with images and video for a quick preview showing the application in action. The review document uses a *template* with fields providing information on how the experience can be applied to particular curriculum topics. Enforced templates and formatting requirements are facilitated by hosting the review ecosystem in an online *platform* that can verify these constraints as the review is created.

Extract details relevant to teachers: *Educationa*l purpose involves assessing experiences for educational value and providing suggestions on how to adapt experiences to resource constrained classrooms. *Quality* measures focus on educational insights and ease of applying information from the review. Review ratings should explicitly measure usefulness of the details provided, which are also relevant when searching for information.

Focused on educational elements: The *focus* of the review is to support the community of educators by collecting and presenting information about the educational properties of the experiences. While the *field* addressed by the review is education, this must include sub-fields corresponding to different topics that are taught.

Validated information: The *usage* of the reviews requires relevant, up to date, and trustworthy information. The ecosystem supports this by presenting details of the evaluation process and reputation of the reviewer. Reputation mechanisms reduce *costs* associated with screening and validating reviews. The ecosystem *structure* has both review writers and users drawn from the teacher population to ensure relevant information is communicated.

This study identifies that the requirements have left out the *challenges* associated with the review ecosystem. *Viability* can only be achieved if the *costs* are managed and if the content remains up to date. This may require including product marketing where there are benefits of having product vendors both promote and facilitate reviews of their products, provided the trustworthiness of the review ecosystem can be maintained. Bootstrapping the system is a challenge where the new platform could be seeded with insights automatically extracted from reviews in existing ecosystems.

These strategies are adapted from those used in existing review ecosystems (see section III for a summary of these). There are opportunities to experiment with innovative approaches specific to eduXR. Having multiple reviewers able to contribute to a single review would ensure that the review represents a greater consensus, incorporates a wider range of discipline expertise, reduces the number of reviews returned by a search, and reduces the effort required by individual reviewers.

C. Limitations

The concept of a review ecosystem for interactive experiences is not yet well established in academic literature. This is further complicated by having the word "review" being very common in academic databases. We ensure that all relevant sources of information are covered using the two phase search strategy that starts with a broad search combined with manual screening. The second phase then uses focused search strings that returns a dense set of relevant results that are checked for saturation. There are a range of existing and emerging game and XR review sites that have not been the subject of academic studies. These can offer further insights into emerging review ecosystems but will not be identifiable by a *literature review* search methodology. Review ecosystems focused on supporting commercial goals through product reviews is also outside our scope.

Research into measures that indicate the quality of an experience *during participation* have been excluded. This is a potential useful area to explore with respect to XR applications since these increasingly have the ability to measure engagement during the experience using body tracking and facilities such as facial and eye tracking being included in more recent devices. Analysis and aggregation of such measures would be particularly relevant to selecting effective eduXR experiences.

This paper investigates the opportunity for a technology transfer from review ecosystems for games to other areas such as eduXR. Established solutions exist for games but the concepts involved may not translate directly to eduXR. The findings only provide a basis for the deliberate design of a stable and useful eduXR review ecosystem where it is possible to adapt the insights gained from game review ecosystems.

D. Opportunities

The analysis (see section III) leads to the synthesis of a set of options that can be considered when building new review ecosystems. These are summarized in Figure 13. However, the choices that do not exist in any existing system provide opportunities for further innovation with respect to review ecosystems.

The stage at which an *experiential review* is created (before the experience based on other reviews, during development of the experience, during or after the experience, immediately after, or on reviewing recordings) shapes the review ecosystem. An *experiential review* is not a standalone entity. Each review is influenced and informed by different factors including past experiences, past reviews read, how often you've played the game, how experienced you are as a gamer, your profession, and your motivation for creating the review. It is only when you know this contextualizing information that you can interpret the review in a meaningful way. Since everybody sees the world differently, the process for creating an *experiential review*, including whether certain contextualizing information be included, can emphasize consistency in communicating concepts, uncover aspects that may be assumed to be obvious, or present an interpretation of the experience as understood by that participant. A review ecosystem is a mechanism to collate diverse opinions to yield collective insight and these

Review Ecosystems

Structures and Opportunities

Purpose

Topic	Choices
Goal	gaining understanding, sharing insights, collating information, conducting assessment and promoting products
Strategy	encourage informal reporting by participants, follow set processes with groups of reviewers, apply consistent and rigorous evaluations across the entire ecosystem
Value	later analysis, preset purpose

Form

Topic	Component	Choices
Format	Structure	free-form text, defined sections, case study, numerical ratings
	Media	documents, comment streams, images and video, interviews, captured game play, virtual environment
Template	Goal	gaining understanding, sharing insights, collating information, conducting assessment, promoting products
	Process	informal reporting, set processes, rigorous evaluations
	Value	opportunistic analysis, defined purpose
	Scale	multiple reviewers, multiple games, aggregation
Focus	inform others, contribute to the community, show status, reflect on game designs, influence purchases, promote products, provide feedback to developers, report problems, evaluate educational experiences, categorize games	
Field	Platform	mobile, desktop, ...
	Category	multiplayer, serious, simulation, therapy, ...
	Field	virtual reality, augmented reality, mobile applications, health, journalism, ...
	Dimension	play experience, narrative, addiction, ...

Utilitization

Topic	Choice	Condition
Target audience	designers and developers	if reasoning about games
	customers and publishers	if marketing and selling games
	reviewers and players	if discussing the play experience
	teachers and students	if using games to support education
	researchers	if investigating reviews and understanding games
	specialists	if wanting to find experiences
	health professionals	if using games for therapies

Topic	Component	Choices
Usage	Information	insights to guide developers
	Analysis	supplying multiple reviews, structured information extraction
	Support	describing game play strategies, support for dealing with problem
Education	measuring educational value, adapting experiences for education, educational outcomes through reviewing	
Mechanics	Source	number of games per review; reporting/assessing/refining a design, determining the background, reviewer professional experience, reviewer bias
	Rigor	reviewer credibility, experience with gaming and the game, review structures and standards, levels of objective versus subjective content
	Tools	presenting ratings/short comments/long reviews, tools for analysis and/or reporting
	Timing	aggregation of other reviews before playing, during play, immediately after play, after signicant amounts of play, long after play based on nostalgia, after watching recordings of others playing

Ecosystem management

Topic	Component	Choices
Structure	Writer's purpose	rating, recommending, repurposing, reasoning, refining
	Reader's goals	decision making, identifying the effects of design decisions, measuring value
	Review modifiers	translating reviews so they can be used for additional purposes
	Review medium	paper, restricted online, open online
	Hosting environment	once-off specialist repository, curated collections, with market, specialist review ecosystem
Incentives	Participation	review creation, rating of reviews and reviewers, community engagement
	Incentive	financial, community status, career progression, self-interest including promotion and marketing products, collaboration and cooperation, wisdom of crowds, free stuff, scarcity, personal growth
Value	Intrinsic reward	status, altruism, improved play experiences
	Extrinsic reward	money, improvements in quality of game experiences, ability to identify relevant games)
	Commercial benefit	improved development processes, higher product quality, validated targets for evaluating products, increased sales with less marketing effort
	Community reward	support from other community members, emergent benefits of aggregated reviews
	Specialist rewards	can identify and adapt games for specialist purposes, can share evaluation tools
	Production costs	costs, review curation, hosting
	Management effort	managing quality and accuracy, setting community standards
	Utilization overheads	accessing sets of reviews, extracting insights from free-form text
Quality	Review properties	quality, taxonomy fit, validity
	Metadata	reviewer reputation, sales levels
	Review of reviews	helpfulness
	Review collections	aggregation, statistical measures, correlation, ranking, trend predictions
Environment	Platform	online sales/portal/media/comment stream, restricted online, community, printed media
	Services	downloadable reviews, ranking, review search
Viability	Viability measures	longevity, number of reviews, number of users, rate of reviewing, rate of usage, product sales
	Viability strategies	combining product sales with reviews, paid reviewers, integrated with social media, advertising, professional practice requirements
Challenges	Overheads	for creating reviews, curating them, validating
	Managing reviewers	amateur/professional, motivation, experience, reputation
	Standards	one/many contributor per review, formal or ad hoc, defined topics/free text, rankings and/or qualitative opinions, one/many game per review, long detailed reviews or short comments
	Utilization	rankings for reviews, sharing, analysis processes, reuse and repurposing

Fig. 13. Guidelines for the construction of review ecosystems.

options can be selectively varied to account for a particular perspective.

The *experiential review* ecosystems are diverse despite the focused keywords used to identify the sources for this *literature review*. This variety applies to the form of a review, the ways in which they are used and the motivation to create and consume them. Even so, an *experiential review* is still part of an even larger system when considered within a socio-cultural-historical perspective [110]. Reviews have the unique property of providing a proxy for an experience. The influences that affect the creation of an *experiential review* extend beyond the review ecosystem to include the broader background of the reviewer, their society and culture, and their context at the time of writing. Existing review ecosystems do not capture this background even where it would be relevant in selecting and interpreting *experiential review*s. For example, knowing that a reviewer is an experienced educator, with a long history in trialing or using digital technologies in the classroom, would be relevant in assessing the review of an XR experience (with respect to teaching a particular topic) for readers in similar occupations. The associated opportunity is: capture and present context relating to the reviewer and their influences to support interpretation of what is in the review (and what might be excluded).

The *literature review*s cited [27, 23, 24, 8] focus directly on the analysis of existing games and XR experiences but also set the precedent for analysing existing academic case studies to perform a *literature review* of *experiential review*s. Analysis of game reviews using, for example, data mining works across a broad set of reviews with the goal of measuring properties of *experiential review*s. An opportunity exists: use *literature review* methodologies applied to *experiential review*s to identify trends across classes of game (e.g., in the same genre, or representing evolution over time of game designs or mechanics). This introduces challenges around the reliability of *experiential review*s as they represent a form of gray literature, but offers value in providing rigour within review ecosystems and applying evidence based direction to the design of eduXR experiences. Computing educators are well positioned to anticipate and exploit the value that arises from access to a well-structured data set. Reviews are a tool that is used for many purposes, beyond just describing and recommending, and can support search and selection, compare properties and features, describe how to adapt and repurpose experiences for other purposes, provide feedback and quality control, give insight into an experience and provide personal growth and connections.

The complexity of a general purpose review ecosystem is a challenge when constructing a new one. Specialist areas, such as eduXR, would be best advised to focus on a single core focus across each of the dimensions (as in section V-B). The classification of review ecosystems provides further value by enabling categorization according to the classification scheme in Figure 13. This provides a language to describe and reason about existing systems in order to identify suitable systems for particular purposes. It allows opportunities to identify systems that provide part or all of the functionality of a review ecosystem. For example, the academic publishing environment has been shown to be a review ecosystem in this paper.

The focus in this paper is on being able to identify and employ an ecosystem of *experiential review*s specifically focused on eduXR experiences. Mature environments exist for gaming reviews. These can incorporate eduXR experiences although bespoke communities are starting to emerge in this category. The significant opportunity resulting from this study is to: create an eduXR *experiential review* ecosystem that captures and presents relevant information, provides the insights required to select and deploy eduXR experiences, and ensures that a strong social community is built with ethical incentive mechanisms that benefit all stakeholders.

E. XR Review Ecosystems

XR reviews are currently treated as part of existing game review ecosystems. However, XR has some fundamental differences, as illustrated in Figure 2. The design strategies for XR review ecosystems are based on a range of existing review systems, including product reviews, peer review and gaming review communities. The resulting review guidelines (Figure 13) also reflect the opportunities that have been identified for XR. The form of the review extends beyond text and video to capture immersive representations. Review structure includes concepts from game play but extends these to other templates that include fields relevant to areas like eduXR (e.g., curriculum and assessment). The utilization of XR reviews deals with more than content consumption and entertainment. Reviews for XR are particularly relevant to areas of training and tourism. Specialist XR systems connect stakeholders, such as educators to developers and publishers, as XR applications can be relevant to multiple markets. Social XR applications lend themselves to collaborative review review structures, with immersion further developing trust.

This paper does not prescribe a single XR review ecosystem but presents a systematic approach to creating bespoke environments intended for specific purposes. This work enables further focused research into innovative strategies such as collaborative reviews, within-experience reviews, and customized feedback loops between stakeholders.

F. Contributions

This paper collates concepts from research into reviewing strategies for use as components of a complex emergent system. This exposes issues such as stakeholder roles, varied incentive mechanisms, choice of evaluation metric and structures for feedback loops. The collected strategies and options can now be used for purposefully creating review ecosystems. This framework did not exist previously, resulting in many electronic platforms still replicating the text heavy, archive style review environments derived from paper-based publishing. All options are linked to their underlying research source (see Appendix III). Opportunities afforded by considering reviews at a system level are identified and discussed throughout sections IV and V-D. These result from the analysis which considers not only each component, but also the potential interactions between the components.

This work focuses on review structures suited to XR and eduXR, supported by the case study in section 4.2. The use of reviews to efficiently find and adapt XR experiences to support teaching is a particular focus. The scope of a review ecosystem extends past the sales focus of commercial ratings systems to include many aspects of the community focused review systems developed for games. XR can be a medium for communicating reviews, can provide ways to collate, present and evaluate information relevant to XR, and opens opportunities to pioneer the inclusion of a review ecosystem as part of the consumption of XR experiences.

VI. Conclusions

This paper presents a scoping review that catalogs existing practices in preparing, presenting and maintaining a set of *experiential review*s in an *experiential review* ecosystem. Given the lack of prior research into eduXR review ecosystems, this process systematically identified relevant literature from the adjacent field of game reviews. Each source is analyzed with respect to a range of criteria within the categories of form, utilization and ecosystem management. A detailed analysis is provided in section III with the resulting components and design choices listed in section IV. This review achieves two goals:

1) Identify and describe trends related to *experiential review* ecosystems: The review draws insight primarily from established game review ecosystems and also considers novel variations of these, as well as review systems within education and academia. Popular strategies that integrate review systems into other platforms benefit from the resulting social structures, use structured text based reviews suited to data mining, and avoid conflicts of interest that damage the vital ingredient of trust. Opportunities for innovation include devising measures of review quality that provide appropriate incentives, improve rigour and value through multiple reviewers or comparative reviews, integrate the review with the interactive experience to provide supporting evidence, and connect even more pairs of stakeholder roles with mutually beneficial relationship structures.
2) Present practices for establishing *experiential review* ecosystems: Section V-B illustrates the process for designing a custom ecosystem based on particular requirements. Figure 13 provides the categories to be considered and the choices to be made. Examples of the practice associated with each choice are provided through the citations linked the corresponding tables and discussions in sections III and IV.

The categorization of eduXR review ecosystems in this paper provides a tool for reasoning about such systems. Existing approaches can be classified according the criteria and options shown in Figure 13. The merits of different strategies can be compared within each category and the alternative options presented can be considered as strategies to refine and improve existing systems, and to support the design and development of new review eduXR ecosystems.

This *literature review* shows that there is only a small amount of existing research into review ecosystems [21, 39, 2, 8], and that these ideas have not been significantly developed. While automated analysis of existing review ecosystems is common, this paper represents the first steps in presenting strategies for deliberately constructing review ecosystems to facilitate their collective use.

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