4 Prior Knowledge, Competence, and Differentiated Game Design

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4.1 From Zero-Entry Designs to Experience-Dependent Architectures

This chapter focuses on prior knowledge as a decisive design variable, distinguishing zero-entry experiences from mechanics that require established competence, achievement orientation, and differentiated learning pathways.

Any serious account of game-based learning must eventually confront a variable that much of the general literature treats with insufficient precision: the prior knowledge that the learner brings to the game before the game begins. The question is not merely psychological not simply a matter of confidence, curiosity, or affective readiness but epistemological and structural. It concerns the relationship between what the learner already knows and what

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the game is capable of teaching, and it has direct implications for the design of instructional games at every level of complexity.

The simplest formulation of the problem runs as follows. A game designed for educational purposes is not a neutral container into which any learner may step with equal facility. It is, rather, a structured environment whose internal logic presupposes certain cognitive resources in the player. Some games presuppose very few such resources; others presuppose a great many. The character of the learning experience and, more fundamentally, whether learning occurs at all depends in considerable part on the alignment or misalignment between what the game demands and what the learner already possesses. This alignment is not automatic. It must be designed for, and designing for it requires a taxonomy of games according to the prior knowledge they presuppose.

At one end of the spectrum sit what may be termed zero-entry games: instructional designs that require no domain-specific prior knowledge and that construct the conceptual apparatus of the subject from first principles within the game environment itself. The learner arrives, in the relevant sense, empty or at least, the game proceeds as though they do, requiring nothing beyond the general cognitive capacities that any adult or adolescent learner may be presumed to possess: the ability to follow rules, to observe consequences, to form elementary hypotheses, and to revise them in the light of feedback.

Zero-entry games are most naturally suited to the introduction of opening concepts ideas that are, by definition, prerequisite to everything that follows in each domain, and that therefore cannot themselves presuppose prior domain knowledge without generating an infinite regress. They are also, it should be noted, the most discussed category in the general literature on game-based learning, perhaps because they are the most tractable to experimental study: the absence of prior knowledge as a confounding variable simplifies the measurement of learning gain.

A canonical example from the natural sciences is the family of games designed to introduce the concept of natural selection. This pedagogical logic of building concepts from the inside out through structured game experience is closely aligned with what Barab et al. (2009) call transformational play: environments in which learners are positioned as protagonists who must apply academic knowledge to solve problems that matter within the game world, thereby constructing understanding through consequential action rather than passive reception. Games such as *Birdstrike* or the earlier *Evolution* simulations ask players to manage populations of organisms across successive generations, allocating traits and observing differential survival rates. The player need not bring no prior knowledge of genetics, population biology, or evolutionary theory. The game constructs these concepts ostensively through the accumulation of experience within the simulation rather than propositionally. The player does not read that organisms with advantageous traits survive at higher rates; they observe it, repeatedly, as a consequence of their own decisions. The conceptual content emerges from the experience of play rather than preceding it.

A parallel example from economics and social science is the *Trading Game*, long used in development education, in which groups of learners are allocated unequal resources and tasked with producing goods through exchange. No prior knowledge of comparative advantage, terms of trade, or market structure is required. The game generates, through the friction of negotiation and the visibility of outcome disparity, an experiential ground from which these concepts can subsequently be abstracted. The teacher's role, in such designs, is not to transmit the concept before the game begins but to name and formalise it after to provide the conceptual vocabulary that the learner now has an experience to attach it to.

This is the distinctive epistemological structure of the zero-entry game: it produces knowledge from the inside out, beginning with experience and proceeding toward abstraction, inverting the traditional sequence of instruction in which abstraction precedes and conditions experience. It is, in this respect, aligned with constructivist theories of learning, and its pedagogical power derives precisely from the fact that it does not demand prior knowledge as a condition of entry. The learner's ignorance is not an obstacle; it is, in a carefully designed zero-entry game, the very resource the game is built to transform.

4.2 Variable Prior Knowledge and the Conditions of Meaningful Play

The situation changes substantially and the design requirements become correspondingly more complex when the game presupposes prior domain knowledge as a condition of meaningful engagement. Here the learner's existing cognitive structures are not merely a biographical fact but a functional prerequisite: the game cannot be played meaningfully, and the learning it is designed to produce cannot occur, unless the player brings to it a sufficient base of prior knowledge on which the game's demands can operate.

This category of game represents, it should be argued, the majority of instructional games designed for advanced secondary or tertiary education, and its relative neglect in the introductory literature reflects a bias toward novice learners that the field has not always been transparent about. When prior knowledge is a structural variable rather than an incidental one, the design of the game must grapple with questions that zero-entry designs can comfortably ignore: What does the player need to know before the game begins? How variable is that prior knowledge across a given population of learners? And how does variability in prior knowledge translate into variability in the learning experience the game produces?

Consider a medical education example. Simulation-based games designed to develop clinical reasoning such as those used in virtual patient platforms like *Body Interact* or *SimMan* presuppose a substantial base of anatomical, physiological, and pharmacological knowledge. A learner who approaches such a simulation without having first internalised the relevant organ systems, disease mechanisms, and drug interactions will not merely perform poorly; they will be cognitively unable to engage with the game's decision structure in the way the design intends. The game presents a patient with chest pain and requires the learner to order investigations, interpret results, form a differential diagnosis, and initiate treatment. Each of these steps requires not curiosity but knowledge specific, structured, retrievable knowledge that has been encoded through prior study and that the game now asks to be activated, applied, and extended under conditions of uncertainty and time pressure. The prior knowledge is not context for the learning; it is the mechanism through which learning occurs. Without it, the game produces not education but confusion.

A second example, drawn from the domain of history and political science, is the family of negotiation simulations used in international relations pedagogy among the most well-documented being Statecraft and the various Model United Nations formats adapted for digital play. These games require players to represent states in a world-system, conduct diplomacy, form alliances, manage domestic constraints, and respond to international crises. The instructional literature on such simulations consistently demonstrates that their effectiveness as learning instruments is strongly conditioned by the depth of prior knowledge players bring to them. Students who enter the simulation with a working knowledge of the states they represent, the historical precedents that shape their interests, and the formal structures of international institutions engage with the game at a qualitatively different level from those who do not. The former group uses the game to test, apply, and deepen existing understanding; the latter group uses it if they can be said to use it productively at all merely to acquire surface familiarity with a domain whose underlying logic they have not yet grasped. The game, in other words, produces different learning from different learners not because those learners differ in intelligence or motivation, but because they differ in the cognitive resources they bring to the experience.

4.3 Prior Competence, Achievement, and Motivation

In recent years, video games have increasingly come to be recognised as compelling instruments for learning, owing in large measure to their remarkable capacity to draw individuals into immersive educational experiences and to sustain their attention with unusual intensity. The expansion of edutainment, together with the widespread adoption of mobile learning games, has made it imperative to evaluate the educational value of such media and to understand more clearly the behaviours that unfold within gameplay.

The idea that one may learn through play is by no means new. Scholars have long observed that play allows children to rehearse social situations, to explore emotional possibilities, and to encounter forms of resolution that extend beyond the immediate boundaries of the play experience itself. In this sense, play is not merely an intrinsically motivating activity; it is also a means through which children construct alternate realities shaped by perception, imagination, and desire. It offers a symbolic space in which real-life tensions, frustrations, and unmet wishes may be negotiated and, at times, temporarily resolved.

Video games intensify these formative qualities through the distinctive affordances of the digital medium. Their interactivity invites players not simply to observe a narrative, but to inhabit it actively: to pursue goals, make decisions, confront challenges, and experience the consequential sense of agency that emerges from meaningful participation. Among the many elements that scholars have identified as contributing to video game enjoyment, the experience of self-efficacy remains critical. When children engage in gameplay, they may develop competencies that foster persistence, satisfaction, and a heightened sense of mastery. Even more significantly, games create conditions in which curiosity may be gratified and achievement felt in immediate and tangible ways.

Enjoyment, indeed, lies at the heart of entertainment, and video games are no exception. People turn to entertainment media above all in search of enjoyment, and gaming derives much of its appeal from the pleasure inherent in the act of play itself, regardless of whether success is ultimately attained. Yet enjoyment is not merely a desirable by-product of gameplay; it is a necessary precondition for continued engagement. A player is unlikely to return to an activity that is not experienced as enjoyable, and without such enjoyment, motivation and persistence are markedly less likely to endure. For this reason, enjoyment assumes a central role in achievement: it encourages players to continue learning, refining, and mastering the game, whereas boredom or dissatisfaction often lead to disengagement and, consequently, to failure in learning.

Within the literature on motivation and achievement, perceived competence has attracted sustained scholarly interest. Dweck and Leggett (1988), among others, have shown that perceptions of competence are closely intertwined with implicit theories of ability and with the goals individuals pursue in achievement settings. Motivation research has therefore approached competence from multiple angles: as the desire to become competent, to appear competent, to feel competent, or to avoid appearing incompetent in the eyes of others. Video games provide especially fertile ground for such processes, as they offer repeated opportunities for trial, error, feedback, adjustment, and eventual success. A player's experience of competence often emerges when accomplishment is attributed not to chance, but to personal effort, skill, and strategic adaptation.

Empirical work further suggests that enjoyment is closely linked to the satisfaction of the basic psychological needs identified in Self-Determination Theory, namely autonomy, competence, and relatedness. Research has shown that the fulfilment of these needs not only correlates with enjoyment but also explains a considerable proportion of its variance. From this perspective, enjoyment may be understood not simply as pleasure, but as the experiential consequence of intrinsic need satisfaction.

It is against this theoretical backdrop that the present study investigates the factors likely to influence both enjoyment and achievement in a mobile learning game. Drawing upon Cognitive Evaluation Theory, Bandura's (1986) Social Cognitive Theory, and Harter's (1978) Theory of Competence Motivation, the study develops a conceptual model through which these relationships may be examined. In doing so, it contributes to research on media enjoyment by incorporating variables such as game attitude, prior experience, and intensity of use, all of which have received comparatively limited attention in earlier models. Moreover, while much of the existing literature has focused on voluntary engagement with entertainment games, less is known about how students are motivated and how they achieve intended outcomes when gameplay is assigned within educational contexts.

Accordingly, the study is guided by three central research questions: first, which factors shape enjoyment and achievement in a mobile learning game; second, how perceived competence relates to an individual's attitude toward the game and frequency of play; and third, how prior experience contributes to the development of perceived competence.

Self-Determination Theory provides an essential framework for understanding these dynamics. According to Ryan and Deci (2000), both intrinsic and extrinsic factors may either support or undermine motivation. One of its mini-theories, Cognitive Evaluation Theory, proposes that events and conditions which enhance an individual's sense of competence and autonomy strengthen intrinsic motivation, whereas experiences that diminish these perceptions weaken it. At its core lies the principle that changes in one's perception of competence directly influence intrinsic motivation, which in turn gives rise to feelings of enjoyment and interest. In games and sports alike, intrinsic motivation appears to be the central motivational force. Unlike many other activities, gaming is not only intrinsically motivating but also uniquely structured to satisfy psychological needs. Players rarely seek rewards external to the game; indeed, they often willingly pay for the opportunity to participate in the gaming experience itself. It therefore seems reasonable to suggest that games are pursued, above all, as sources of intrinsic satisfaction.

In this context, perceived competence has often been discussed alongside self-efficacy. Both constructs are associated with goal pursuit, behavioural engagement, skill development, and learning. Yet competence, particularly in the language of Self-Determination Theory, extends beyond the simple possession of skills. It includes an individual's appraisal of their ability to coordinate those skills effectively in meaningful and challenging situations. Self-efficacy, by contrast, has often been treated as a more strictly cognitive perception of one's capability to perform a task. Even so, the two remain deeply related in the study of motivation and achievement.

Prior game experience is one factor expected to shape perceived competence. Researchers have argued that earlier gaming experience, together with the development of skills such as spatial reasoning, problem-solving, reaction speed, and control accuracy, can substantially affect gameplay behaviours and learning outcomes. Yet competence should not be reduced to the possession of such skills alone. Rather, it concerns one's confidence in mobilising them under changing and demanding conditions. The interactivity of games, and the player's ability to make an impact within the virtual world, may produce a strong sense of control, agency, and efficacy. Since perceived competence in any domain develops through a history of successes and failures, it is reasonable to assume that mastery experiences in gaming contribute to stronger competence beliefs over time. Prior research in adjacent domains, such as information technology, supports this proposition, showing that experience-based mastery is positively associated with self-efficacy. On this basis, the study proposes the first hypothesis: that prior game experience will be positively related to perceived competence.

Perceived competence is also expected to influence attitude toward the game. Educational research has consistently regarded attitude toward a subject as an important predictor of performance. Students' attitudes are central to the achievement of educational goals, and the successful integration of digital games into instructional settings depends in no small part on the perceptions students hold toward such media. If learners are to use games as educational tools, their attitudes toward them must be monitored with care. Positive perceptions of competence may dispose players to welcome challenge, acquire new skills, and form favourable judgments about the gaming experience. Although empirical work directly linking perceived competence and game attitude remains limited, existing studies suggest that more competent gamers tend to report more positive attitudes toward computer games and technology more broadly. The second hypothesis therefore posits that perceived competence will be positively related to game attitude.

A related relationship concerns the intensity of game use. Bandura (1997) argued that individuals with stronger self-efficacy beliefs are generally more active and more persistent in their efforts. Feelings of competence within gameplay may therefore strengthen intrinsic motivation and encourage sustained engagement. Those who perceive themselves as capable are more likely to involve themselves in tasks that offer challenge and permit the pursuit of self-referenced goals, whereas those who feel less competent may withdraw from such opportunities. Intensity of use may thus be understood in two complementary ways: as repeated exposure to situations that reinforce competence, and as an outward sign of a player's willingness to continue participating because past experiences within the game have been marked by achievement and mastery. Studies in the field of computer technology have found that individuals with higher self-efficacy tend to use computers more frequently. Extending this logic to gaming, the third hypothesis proposes that perceived competence will be positively related to intensity of use.

Perceived competence is further expected to shape enjoyment. In Harter's (1978) Theory of Competence Motivation, competence is understood as a need for challenge and reflectance, and successful attempts at mastery are thought to strengthen perceived competence while simultaneously enhancing intrinsic motivation. Individuals who feel competent are naturally drawn to remain involved in an activity, and Harter argued that those who regard themselves as highly competent in an achievement domain experience more positive affect. To demonstrate competence is, in a meaningful sense, to encounter joy. Previous research has repeatedly shown positive relationships between perceived competence and enjoyment across a variety of contexts, including physical education and digital gaming. Particularly relevant is work showing that perceptions of in-game competence and autonomy are significantly associated with game enjoyment. The fourth hypothesis, therefore, states that perceived competence will be positively related to enjoyment.

Finally, perceived competence is expected to contribute to gaming achievement itself. The logic here parallels achievement processes in formal education. In schools, achievement is rewarded through mastery, progression, and external affirmation from teachers and parents. In games, comparable rewards are found in mastery of mechanics, advancement through levels, and recognition from peers. Players who perceive themselves as competent are more likely to persevere when faced with failure, to recover quickly from setbacks, and to continue striving toward the goals they have set for themselves. Such persistence reflects achievement motivation in its clearest form: the drive to pursue excellence through repeated effort and engagement with difficult tasks. In gaming, this motivation manifests as the willingness to practise, to fail, to try again, and ultimately to master the skills required for success. Empirical studies in educational settings have already demonstrated strong links between perceived competence and achievement outcomes. On this basis, the fifth hypothesis proposes that perceived competence will be positively related to achievement.

The present study proposed a conceptual model grounded in Cognitive Evaluation Theory, Bandura's (1986) Social Cognitive Theory, and Harter's (1978) Theory of Competence Motivation in order to examine the extent to which enjoyment and achievement in a mobile learning game may be predicted by an individual's perceptions of competence. In addition to competence, the model incorporated several related variables, namely prior gaming experience, intensity of use, and attitudes toward computer games, all of which proved to be significantly associated with how competent players perceived themselves to be.

It is important to note, however, that media enjoyment is not a simple or linear phenomenon. Touati and Baek (2018) investigated precisely these questions in a mobile learning game context, finding that perceived competence, game attitude, and intensity of use collectively predicted both enjoyment and achievement, a result that highlights the interdependence of motivational and cognitive dimensions of gameplay. As Vorderer, Klimmt, and Ritterfeld (2004) have observed, enjoyment constitutes a complex process, shaped by multiple psychological dimensions rather than by any single causal mechanism. For this reason, the model advanced in this study does not seek to reduce enjoyment to a fixed sequence of effects. Its purpose, rather, is to illuminate some of the principal constituents of game enjoyment, with particular emphasis on the combined role of perceived competence and game attitude. At the same time, the model demonstrates that achievement, a central concern within any learning environment, is not separate from enjoyment but directly connected to it. In this respect, the findings also offer empirical support for the conceptualisation of enjoyment as an attitude, as proposed by Nabi and Krcmar (2004), according to which enjoyment emerges from the interaction of cognitive, affective, and behavioural dimensions.

As anticipated, the strongest relationship in the model was found between prior gaming experience and perceived competence. This result is especially revealing. Most participants evaluated their *Minecraft* skills as either moderate or high, suggesting that they possessed well-established beliefs in their capacity to coordinate the skills they had acquired through earlier gameplay. The finding accords closely with the broader literature, which has consistently shown that previous mastery experiences contribute substantially to self-perceptions of competence. From an educational standpoint, the implication is clear: instructors and designers must attend carefully to students' prior familiarity with particular types and genres of commercially available games before integrating them into formal learning settings. The greater the learner's previous experience with a game, the more likely that learner is to approach the experience with a stronger sense of competence.

The model also examined the relationship between perceived competence and attitude toward the game, and here too the results were unequivocal. Students who regarded themselves as more competent also expressed more favourable attitudes toward the game. This finding echoes earlier research suggesting that competent gamers are generally more disposed to evaluate computer games positively. Such an outcome is particularly important in educational contexts, where attitudes toward a medium may significantly influence whether it is embraced as a legitimate and effective learning tool.

Beyond this, the study demonstrated that students who held more positive attitudes toward computer games also reported higher levels of enjoyment. This result is consistent with previous research in the field of technology use, which has identified a positive association between favourable attitudes and enjoyment. Yet the significance of the present finding lies in the fact that it does more than merely replicate earlier observations: it suggests that game attitude may itself act as a predictor of enjoyment, thereby indicating a reciprocal relation between the two. Enjoyment may shape attitudes, but attitudes may also predispose individuals toward enjoyment. Such a relationship lends further empirical weight to the view of enjoyment as an attitudinal construct, one composed of intertwined cognitive judgments, affective responses, and behavioural inclinations. Significantly, these same three dimensions were reflected in the scale used in the study to assess participants' attitudes toward games.

With regard to the relationship between perceived competence and intensity of use, the results likewise confirmed the study's expectations and aligned with the existing literature. Participants who viewed themselves as highly competent had engaged with the game more frequently. This finding is readily intelligible within the framework of Bandura's (1986) Social Cognitive Theory, which holds that individuals with stronger perceptions of self-efficacy are generally more active, persistent, and committed in the activities they undertake. In the context of this study, intensity of use, measured through the number of hours students devoted to gameplay, may be interpreted as an expression of their willingness to confront challenging tasks that, while demanding, remained within the bounds of their perceived abilities. It also reflects their capacity to persist in the pursuit of clearly defined goals. In this respect, the study's findings are in keeping with prior work showing a positive relationship between computer self-efficacy and frequency of computer use. What the present research adds is the validation of this same principle within the more specific domain of mobile game-based learning. These findings reinforce the central role of perceived competence within the ecology of game-based learning. Competence does not function merely as an isolated psychological state; rather, it appears to occupy a pivotal position from which a range of related outcomes emerge. It is shaped by prior experience, expressed in patterns of continued use, and reflected in the attitudes learners form toward the gaming medium itself. Most importantly, it intersects with both enjoyment and achievement, thereby linking motivational and educational processes in a particularly meaningful way.

What emerges, then, is a vision of mobile learning games not simply as entertaining tools, but as environments in which prior knowledge, self-belief, emotional engagement, and behavioural persistence converge. If students enter such environments already feeling capable, they are more likely to approach the experience positively, to persist in it, to enjoy it, and ultimately to achieve within it. The educational significance of this conclusion is considerable. It suggests that successful game-based learning depends not only on the design of the game itself, but also on the learner's experiential history and on the psychological meanings that gameplay acquires for that learner. In this sense, competence is not merely one variable among many; it is the axis around which the learner's entire relationship to the game may begin to turn.

4.4 The Knowledge Base as a Prerequisite for Deep Play

This observation points toward a principle that the literature has formulated in various ways but that deserves to be stated with some directness: in knowledge-intensive game-based learning environments, the quality of play is a function of the quality of preparation, and preparation means the prior acquisition of domain knowledge that the game will subsequently mobilise. The game does not replace this preparation; it builds upon it. It is, in the most precise sense of the term, a 'transfer environment', a space in which knowledge already acquired in one context is retrieved, reorganised, and applied in another. The learning that occurs is not the learning of new facts but the deepening of existing understanding: the discovery of relationships between concepts previously held in isolation, the testing of theoretical propositions against the resistance of simulated reality, the development of judgment in conditions where knowledge alone is insufficient and where its application requires the exercise of real reasoning.

This distinction between knowledge acquisition and knowledge mobilisation is fundamental to understanding why prior knowledge is not merely a predictor of game-based learning outcomes but a structural condition of the kind of learning that the most sophisticated instructional games are designed to produce. A game that requires prior knowledge is not a more demanding version of a game that does not; it is a different kind of educational instrument, operating on a different epistemological register. Where the zero-entry game produces knowledge from experience, the experience-dependent game produces understanding from knowledge and understanding, as any educator who has grappled with Bloom's upper taxonomy will recognise, is a qualitatively different achievement from the possession of information.

A third example serves to make this concrete. In legal education, the use of moot court simulations and case-based negotiation games increasingly delivered in digital, or hybrid formats depends entirely on the prior acquisition of substantive legal knowledge. A simulation of contract dispute resolution, for instance, requires the learner to have internalised the doctrinal categories of offer, acceptance, consideration, breach, and remedy before the game can function as a learning environment for the higher-order skills of legal argument, strategic reasoning, and professional judgment. The game does not teach these categories; it assumes them. What it teaches and what no amount of doctrinal study alone can teach with comparable efficiency is the capacity to deploy those categories under adversarial conditions, to recognise the moments at which doctrine must yield to strategy, and to understand, through the experience of defeat as well as victory, that legal reasoning is never merely the application of known rules to known facts.

4.5 Designing for Knowledge Variability: The Problem of the Mixed Cohort

The practical implication that follows from this analysis is one that instructional designers and teachers alike must confront honestly: when a game presupposes prior knowledge, and when the learner population is heterogeneous with respect to that knowledge, the game will not produce equivalent learning across the cohort. This is not a failure of the game; it is a structural consequence of the relationship between prior knowledge and the depth of play the game makes possible. It does, however, generate a real design problem.

Several responses to this problem are available in the literature. The first is sequential design: the deliberate construction of a learning pathway in which the game is positioned as a culminating or integrative activity, preceded by explicit instruction that ensures all learners have acquired the prerequisite knowledge base before the game begins. This approach preserves the integrity of the game's design but requires careful attention to the alignment between the preparatory instruction and the game's specific knowledge demands. The second is adaptive design: the construction of game environments that dynamically adjust their complexity and knowledge demands in response to the player's demonstrated competence, providing scaffolding for less-prepared learners while extending challenge for more advanced ones. This approach is technically demanding and, in its fully realised form, remains more an aspiration than a widespread reality, though developments in intelligent tutoring systems and adaptive game mechanics have brought it closer to practical implementation. The third is explicit differentiation: the acknowledgment, at the level of task design and assessment, that learners with different levels of prior knowledge will engage with the game differently, and that this differential engagement represents not inequity but the natural consequence of different stages of development within a domain.

None of these responses dissolves the fundamental relationship between prior knowledge and the quality of game-based learning. They manage it with varying degrees of elegance and effectiveness but they do not transcend it. The relationship remains. Prior knowledge is not a nuisance variable to be controlled out of the study of game-based learning; it is one of its constitutive conditions, and any account of how games teach that fails to take it seriously will be, in direct proportion to that failure, an incomplete account.

4.6 A Framework for Distinguishing Zero-Entry from Knowledge-Dependent Game Mechanics

Any attempt to build a coherent framework for distinguishing zero-entry games from knowledge-dependent ones must begin by resisting a temptation that is, in the context of educational design, almost irresistible: the temptation to treat the distinction as a simple matter of difficulty. It is not. A game can be extraordinarily difficult without presupposing prior domain knowledge, consider the cognitive demands of *Tetris*, or the strategic complexity of Chess at its highest levels, both of which are, in the relevant sense, self-contained worlds whose rules generate all the knowledge the player needs to engage with them. Conversely, a game can be, in its moment-to-moment mechanics, relatively undemanding, while nonetheless requiring that the player bring to it a substantial body of prior knowledge in order for the experience to produce the learning it was designed to produce. Difficulty and knowledge-dependency are orthogonal dimensions, and a framework that conflates them will misclassify precisely the cases that most need to be distinguished.

The framework proposed here rests instead on five primary dimensions, each of which captures a distinct aspect of the relationship between the game's design and the prior knowledge of its players. These dimensions are not independent of one another, they are, as will become apparent, systematically related, but separating them analytically allows for a precision that treating them as a single undifferentiated variable would foreclose.

The first dimension is what may be called the knowledge entry threshold: the minimum body of knowledge that a player must possess before the game can function as a learning environment rather than merely as an experience. In a zero-entry game, this threshold is, by design, set at or near zero with respect to domain-specific knowledge. The game's internal mechanics are sufficient to construct, from the ground up, whatever conceptual apparatus the player will need. The rules, the feedback loops, the visible consequences of decision, these are the game's primary instructional language, and they speak to any player capable of following them regardless of what that player knew before arriving. In a knowledge-dependent game, the epistemic entry threshold is set substantially above zero. The game's internal mechanics presuppose that certain concepts, relationships, and procedures are already available to the player as cognitive tools, and they operate on those tools rather than constructing them. The threshold is not a flaw in the design; it is, in a well-designed knowledge-dependent game, a deliberate architectural choice that reflects a clear theory of where in the learner's developmental trajectory the game is intended to intervene.

The second dimension is feedback intelligibility: the degree to which the feedback the game provides is interpretable without prior domain knowledge. This dimension is closely related to the first but distinct from it in an important way. A game may have a low epistemic entry threshold, requiring little prior knowledge to begin, but may nonetheless produce feedback that only becomes fully intelligible to a player who already possesses some domain understanding. In a well-designed zero-entry game, feedback is constructed to be self-interpreting: the consequence of an action is visible, immediate, and legible without reference to any external framework. The organism dies because the environment changed and its traits were no longer advantageous; the player sees this happen and the causal logic is embedded in the visual representation itself. In a knowledge-dependent game, feedback frequently requires prior knowledge to be decoded. The virtual patient's oxygen saturation falls following the administration of a particular drug; the learner who does not already know the drug's mechanism of action cannot interpret this feedback as evidence of a specific error in clinical reasoning. The feedback is present and precise, but its meaning is opaque to the unprepared player. It is, in this sense, a message written in a language the player must already speak.

Another dimension is the locus of knowledge construction: whether the primary cognitive work the game requires is the construction of new knowledge from experience, or the application and reorganisation of existing knowledge under novel conditions. This dimension maps most directly onto the epistemological distinction between acquisition and mobilisation that was elaborated in the preceding section, and it is perhaps the most fundamental of the five. In a zero-entry game, the locus of knowledge construction is internal to the game: the player builds understanding through the accumulation of experience within the simulation, moving from concrete encounter to abstract principle through a process that the game's design scaffolds and guides. The game is, in this sense, a complete epistemological environment, a world that generates its own meaning from within. In a knowledge-dependent game, the locus of knowledge construction is partially external to the game: the player arrives with a cognitive structure already in place, and the game reorganises, deepens, and tests that structure by placing it under conditions that formal instruction alone cannot replicate. The game is not a world that generates meaning from within; it is a crucible that transforms meaning already acquired elsewhere.

A different dimension is narrative and conceptual transparency: the degree to which the game's surface narrative or scenario is sufficient to carry the conceptual content, or whether the conceptual content exists at a level of abstraction that the narrative can only partially represent. Zero-entry games tend toward high narrative transparency: the story of organisms competing for survival, the drama of unequal exchange between trading partners, the visible inequality of allocated resources, these surface narratives carry the conceptual content close enough to the surface that a player with no prior knowledge can grasp the connection between what they are doing and what they are learning. Knowledge-dependent games tend toward lower narrative transparency, not because their designs are less careful, but because the concepts they are designed to teach exist at a level of abstraction that cannot be fully materialised in a surface narrative without distortion. A simulation of international treaty negotiation can represent the drama of diplomacy with considerable vividness, but the conceptual structures of neorealist international relations theory, or the formal logic of iterated prisoner's dilemmas in international cooperation, cannot be read directly off the surface of the game experience. They require a conceptual vocabulary that the player must bring to the game in order to see what the game is, at its deepest level, about.

The last dimension is the role of prior experience as generative versus merely facilitative. This is the most subtle of the five, and it requires some care to state precisely. In many accounts of game-based learning, prior knowledge is treated as a facilitator, something that makes the game easier, more accessible, more productive. This framing is correct but incomplete. In the most sophisticated knowledge-dependent games, prior knowledge is not merely facilitative but generative: the learning that the game produces is not simply more learning of the same kind, rendered easier by prior preparation, but a qualitatively different kind of learning that could not occur in the absence of that preparation. The legal student who brings real doctrinal knowledge to the moot court simulation does not merely perform better than the unprepared student; they have a different experience, one in which the friction between doctrine and strategy produces insights of a kind that are, in the strictest sense, unavailable to the student who does not yet possess the doctrinal foundation. Prior knowledge, in such designs, is not the road surface that makes the vehicle run more smoothly; it is the fuel without which the vehicle does not run at all.

These five dimensions knowledge entry threshold, feedback intelligibility, locus of knowledge construction, narrative and conceptual transparency, and the generative versus facilitative role of prior experience are not independent of one another, and understanding their interrelations is essential to understanding how they connect to the broader principles of good game design.

The connection to well-established game design principles becomes visible when one considers what the game design literature, from Salen and Zimmerman's (2004) initial work on rules and play to more recent contributions on meaningful decision-making, identifies as the core requirements of a well-designed game. These requirements include, at minimum: that the player understands the rules sufficiently to act; that actions produce feedback that is interpretable; that the game maintains a dynamic balance between challenge and competence, of the kind that Csíkszentmihályi's concept of flow describes; that the game provides a sense of meaningful progress; and that the game's internal logic is coherent enough to sustain the player's sense of agency, their conviction that their decisions matter and that the game is responding to them rather than merely processing them.

Each of these principles is, it turns out, inflected differently depending on where a given game sits on the spectrum from zero-entry to knowledge-dependent design. The principle of rule comprehensibility, for instance, has a straightforward application in a zero-entry game: the rules must be learnable from within the game, through play, without reference to external instruction. In a knowledge-dependent game, the same principle applies but with a crucial modification: some of the rules, not the procedural rules of the game's mechanics, but the conceptual rules of the domain the game simulates, are not learnable from within the game and must be acquired before the game begins. A well-designed knowledge-dependent game is therefore explicit about this requirement; it communicates clearly to the teacher if not always to the student, what prior knowledge is necessary for the game's rules to be fully intelligible.

The flow principle, the balance between challenge and competence, is similarly inflected. In a zero-entry game, this balance is managed entirely within the game's mechanics, through adaptive difficulty, progressive complexity, or the graduated introduction of new rules. In a knowledge-dependent game, the balance has an additional dimension: the degree to which the player's prior knowledge brings their competence into alignment with the game's demands. A player whose prior knowledge is insufficient for the game's epistemic entry threshold will experience the game not as flow but as anxiety, not the productive anxiety of a challenge at the edge of one's competence, but the paralysing anxiety of incomprehension. A player whose prior knowledge substantially exceeds the game's demands will experience the opposite: not flow but boredom, the disengagement of someone who has been placed below their level. The management of this additional dimension of the flow balance is one of the central design challenges of knowledge-dependent games, and it is one that the literature has not yet resolved with complete satisfaction.

The principle of meaningful agency, the conviction that decisions matter, connects to the framework in a way that is perhaps the most illuminating of all. In a zero-entry game, agency is produced by the game's mechanics: the player acts, the game responds, and the response is visibly connected to the action in a way that confirms the player's causal efficacy. In a knowledge-dependent game, the sense of agency has an additional and more demanding source: it requires that the player understand not merely that their decision produced a consequence, but why it did, A medical student who administers the wrong drug and watches the patient deteriorate has experienced a consequence; but they have experienced meaningful agency only if they understand, through the prior knowledge they bring to the simulation, what went wrong and why. Without that understanding, the consequence is visible but opaque, a reminder of ignorance rather than an occasion for learning.

The framework, considered as a whole, therefore suggests a principle that is both analytically useful and practically actionable: that the design of an instructional game should begin not with the question of what the game will teach, but with the question of where in the learner's epistemic trajectory the game is intended to intervene. A game positioned at the beginning of that trajectory before any domain knowledge has been acquired must be designed to construct knowledge from experience, to make feedback self-interpreting, to carry its conceptual content at the surface of its narrative, and to generate meaningful agency from its mechanics alone. A game positioned further along that trajectory after a body of domain knowledge has been acquired through prior instruction can and should be designed differently: to mobilise rather than construct, to deepen rather than introduce, to make the player's prior knowledge the engine of an experience that formal instruction, however careful, cannot replicate. Both kinds of game have their place. Both can be designed well or badly. But they cannot be designed according to the same principles and treating them as though they can is the most common and the most consequential error in the field.