The Meaning of Challenge

A Cross-Domain Conceptual Analysis for Challenge Based Learning

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Abstract

The word “challenge” is used widely in education, policy, design, engineering, and the media. Educators assign challenges to learners, funders issue challenge-based calls, and engineering and design processes often begin with a challenge. The media report emerging challenges and use them as narrative devices. This broad use suggests a common understanding, yet the term is applied in ways that blur the differences among challenges, problems, opportunities, events, tasks, projects, and threats. The ambiguity has real consequences for Challenge Based Learning (CBL), since the approach’s effectiveness and distinctiveness depend on a precise, shared definition of challenge.

This paper addresses that gap. It applies conceptual framework analysis across nine domains in which challenge is a key construct, among them psychology, adventure education, organizational psychology, public policy, and game design. Etymological and corpus evidence shows that the word has many meanings and that its growth-oriented sense is a twentieth-century layer over older meanings of accusation and summons. The cross-domain analysis, filtered by a necessity test, supports one constituting condition and three essential properties. We propose that a challenge is a situation of real-world significance to a person or group who voluntarily takes it on as their own and commits to a response; its outcome is not predetermined, its demands exceed their present capability while remaining within reach of their perceived resources, and its purpose is their learning and development as much as the difference their response makes.

Volition is the constituting condition. A teacher’s framing, an external brief, or a learner’s own noticing can supply the occasion, and the situation becomes a challenge when those involved take it on as their own. Real-world significance, productive complexity, and growth orientation are the essential properties. The analysis also separates four senses in which CBL uses the word (the challenge statement, the challenge as relation, the challenge unit, and challenging as an orientation) and proposes a shared vocabulary for them. These distinctions offer a diagnostic for design and research. They make explicit the learner’s relation to the situation as CBL’s organizing commitment, which has consequences for how challenges are framed, facilitated, and studied.

Keywords: challenge based learning; challenge-based learning; conceptual analysis; challenge; educational theory; learner agency; pedagogical frameworks

1. Introduction

Challenge Based Learning developed through three lineages, all traceable to the early 2000s. They emerged independently and have remained largely distinct.

The first arose in engineering education at Vanderbilt University and the VaNTH Engineering Research Center. There, a challenge-centered approach grounded in the How People Learn framework produced the STAR (Software Technology for Action and Reflection) Legacy Cycle, a sequence that begins with a challenge and ends by going public (Barr et al., 2005; Bransford et al., 2000; Giorgio & Brophy, 2001). The approach was evaluated in biomedical and biotechnology courses (Jansen, 2003; Martin et al., 2007) and was first called challenge-based instruction (Brophy & Bransford, 2001).

The second lineage dates to 2004. It grounds challenge-based learning in Vygotskian sociocultural theory and presents it as a form of problem-based learning (PBL) with realistic, open-ended problems, proposing the word "challenge" in place of "problem" (Baloian et al., 2006).

The third lineage is corporate. It is anchored in Apple's Classrooms of Tomorrow Today initiative and the white paper that accompanied it (Apple Inc., 2008; Nichols & Cator, 2008), and it was later organized into the three phases of Engage, Investigate, and Act (Nichols et al., 2016). Its first trials ran in schools in 2008 and 2009 with 321 students and 29 teachers, followed by a study that extended the approach from primary to graduate levels (Johnson & Adams, 2011; Johnson et al., 2009).

The three strands have continued in parallel. Apple's definition became the most widely cited, but later work is often difficult to trace to a particular lineage (Perna et al., 2023, p. 7). Some recent accounts suggest that the Vanderbilt and Apple strands converged, with the three CBL phases refining the STAR cycle. The published record does not support this interpretation.[1] Although the lineages share a name and are often cited together, they retain distinct origins, theoretical commitments, and communities of practice. Distinguishing them clarifies which theory, evidence, and implementation guidance a study draws on.

A genealogical review of the engineering education literature identifies three phases in the framework's later development (Martin & Membrillo-Hernández, 2026). In a foundation phase (2001 to 2014), work was grounded mainly in learning science and disciplinary inquiry, and external partners appeared in about one study in eleven. In a consolidation phase (2015 to 2018), the corporate lineage and the grand-challenge discourse became more prominent, and external partnership rose to about forty percent. In an expansion phase (2019 to 2022), externally partnered implementations became dominant at over seventy-seven percent, with industry the most frequently represented partner.

This periodization describes how the engineering and wider science, technology, engineering, and mathematics (STEM) higher education literature represents CBL, which the authors distinguish from classroom practice (Martin & Membrillo-Hernández, 2026, p. 14). Within those limits, it supports a specific claim. Working with people beyond the classroom has been part of the Apple strand from the start: the white paper described CBL as "asking students to work with other students, their teachers, and experts in their communities and around the world" (Nichols & Cator, 2008, p. 1). What became common only recently, and mainly in engineering, is the external partner as the author of the challenge, most often a partner from industry. Industry appears in nearly two-thirds of the partnered studies. Because the review's figures record any partner involvement, the shift in authorship rests on how the underlying reviews describe partners: as presenting challenges and often pre-deciding their topics (Martin & Membrillo-Hernández, 2026, p. 24). Section 8.5 returns to what follows from this.

Two decades on, CBL has produced a substantial implementation literature, an international conference, institutional adoptions on several continents, and a growing body of empirical evaluation. What it has not produced is an agreed account of its own central term.

This is unusual for a pedagogical framework. Problem Based Learning (PBL) theorizes the problem. Its literature contains sustained argument about what makes a problem ill-structured, how ill-structured problems support self-directed learning, and what this means for facilitation (Barrows & Tamblyn, 1980; Hmelo-Silver, 2004; Savery, 2006). Project-based learning (PjBL) theorizes the project, mainly through its driving question and artifact (Blumenfeld et al., 1991; Krajcik & Blumenfeld, 2005; Thomas, 2000). CBL, by contrast, treats the challenge as self-evident. Where definitions appear, they define the framework, its phases, and its outcomes. The challenge itself is described in borrowed terms: an "open-ended problem," a "real-world problem," a "complex problem" (Gallagher & Savage, 2023; Höffken & Lazendic-Galloway, 2024). As a result, the framework's organizing concept is defined as a kind of the very concept CBL claims to differ from.

The field's most cited literature review states the difficulty directly. Gallagher and Savage (2023) observe that "definitions of CBL within the literature tended to describe key characteristics, but an actual definition of a challenge was absent" (p. 1149). They conclude that "in order to fully demark CBL from other approaches, defining the term 'challenge' is crucial" (p. 1150), and add a practical corollary: "practitioners consider what a challenge is at the onset of curriculum design and how it differs from a problem or a project proposal" (p. 1150). To date, that work has received little attention.

The absence has consequences at three levels, which Section 2 develops. In theory, without a definition of challenge, it is hard to show that CBL is a distinct pedagogy and more than a new name for established experiential approaches. In practice, educators asked to design challenges tend to build what they already know, producing projects and problems under a new name. In research, outcomes attributed to "challenges" may belong to repackaged problem- or project-based tasks. This makes findings hard to compare across studies and limits the accumulation of evidence about what, if anything, is distinctive about learning through challenges.

Building on work first presented at the 1st International Challenge Based Learning Conference (Perna et al., 2025), this paper proposes the missing definition. It defines challenge in the context of learning and education, particularly CBL, without claiming to encompass its use in other fields.

Defining challenge from within the CBL literature alone would risk circularity, since the framework's own usage is what is in question. The paper therefore examines how challenge has been theorized in the fields where it does substantial conceptual work. Challenge is a technical construct in psychophysiology and organizational psychology, a design variable in games, a mobilizing frame in science policy, and a cultural form in networked media. Several of these fields have thought about challenge more carefully than education has, and they rarely appear in the CBL literature. The proposed definition brings that work together, with the requirement that it remain usable by educators designing learning experiences.

The paper is organized as follows. Section 2 documents the definitional gap and its consequences. Section 3 describes the method. Section 4 traces the history of the word itself, which helps explain why it resists definition. Section 5 presents the cross-domain analysis, and Section 6 organizes its components and applies a necessity test. Section 7 proposes the definition, distinguishes challenge from related concepts, relates the four senses of the word, and proposes a vocabulary. Section 8 discusses implications for theory, practice, and research, and Section 9 notes limitations and concludes.

The paper takes a constructivist stance. It treats the meaning of "challenge" as historically and socially constructed and dependent on context. This is why a cross-domain survey is an appropriate method, and why the paper makes no claim to have discovered an essence. The claim is narrower and, we believe, more useful. Across a wide range of theoretical traditions, a small set of components recurs. A definition built from those components, with its choices made explicit, can do the theoretical, practical, and research work that Section 2.2 shows CBL cannot yet do.

2. The Definitional Gap

2.1 The conceptual ambiguity of challenge in CBL

The CBL literature presents challenge as the organizing concept of the framework, yet the concept remains only partly theorized. The white paper (Nichols & Cator, 2008) and the later User Guide (Nichols et al., 2016) describe challenges as authentic, open-ended problems that prompt learners to take action on issues of significance. These texts frame the challenge as a bridge between Big Ideas and solutions, a way of turning curiosity into purposeful inquiry. Later reviews reinforce this framing and often define challenges as "real-world" or "ill-defined" problems (Gallagher & Savage, 2023; Höffken & Lazendic-Galloway, 2024).

Explicit definitions in the wider CBL literature follow the same pattern. Van den Beemt and MacLeod (2021) describe the object of CBL as an authentic sociotechnical problem and add that "these authentic problems, also known as 'challenges'" (p. 580) are the work scenarios in which students engage. Ramírez-Cadena et al. (2025) place the challenge in a sequence after the problem, the project, and the practice, and separate it from them by degree. In their account, it is "a more complex structure" and involves "a much greater amount of uncertainty than other teaching models" (p. 502).

These definitions share an unstated assumption: that a challenge is a type of problem, distinguished by greater authenticity, complexity, and uncertainty. The possibility that challenge is a different kind of concept appears only briefly. One example is the definition by van den Beemt et al. (2023): "an activity, task, or situation that represents an incentive and an obstacle to overcome and that requires the development and application of diverse, inter-, and multidisciplinary knowledge to be solved" (p. 2). Because the assumption is never stated, it is never defended.

One of the field's most recent synthesis shows the same pattern. Dikilitaș et al. (2025a) open their practical guide by asking what challenge-based learning is. They answer with twelve characteristics drawn from the User Guide: flexible and customizable, scalable, free and open, learner-driven, authentic, global, relevant, oriented to twenty-first-century skills, technology-integrated, learner-centered, formative, and reflective. Each describes the pedagogy as a whole. A few, such as authentic, relevant, and global, could also describe a challenge, yet the guide applies them to the approach and never says what a challenge is. The term is used throughout without being defined. This is a clear example of characteristics standing in for a definition, and it appears in a text whose stated purpose is to explain the approach to newcomers.

The definition they quote is worth reproducing, since its wording matters for the argument in Section 7.3. Challenge Based Learning is "an engaging multidisciplinary approach to teaching and learning that encourages students to leverage the technology they use daily to solve real-world problems," one that asks students "to ask good questions, develop deeper subject area knowledge, accept and solve challenges, take action, and share their experience" (Nichols & Cator, 2008, p. 1). A parallel formulation describes the approach as engaging students in a real and relevant situation "which involves defining a challenge and implementing a solution" (Tecnológico de Monterrey, 2015, as quoted in Dikilitaș et al., 2025b, p. 4). Both define the framework instead of the challenge, and both use solve and solution to name the work.

The link between challenge and problem has a traceable source. One of the framework's three lineages introduced the term as a substitute, proposing "challenge" in place of "problem" for problems that are realistic and open-ended (Baloian et al., 2006). A word adopted to replace another tends to carry the meaning of what it replaced. The literature has defined challenges as a particular kind of problem partly because that is what the term was introduced to mean. Section 4 shows that the history of the word itself supplies a second, much older source of the same pressure.

A third source lies within the framework itself, and one of the present authors shares responsibility for it. The practitioner texts named the output of the Act phase a solution (Nichols & Cator, 2008; Nichols et al., 2016), and the definition quoted above asks students both to solve real-world problems and to accept and

solve challenges. A solution is always a solution to something, and whatever it answers becomes a problem. Learners asked to produce a solution may therefore reason backward to what it must solve, whatever the Engage phase called the situation. In this way, the vocabulary at the end of the process can override the framing at the start. This may explain a pattern the implementation studies record without explaining: practitioners revert to problems even where the guidance states that a challenge is not a problem. Taken together, these three independent sources of pressure, one lexical, one historical, and one internal, help explain why the conflation of challenge with problem has proved so durable. The definition in Section 7.1 uses response where the framework used solution, and Section 7.3 sets out how the two differ.

The literature has not yet tried to define the challenge as a concept distinct from the problem. Gallagher and Savage (2023) note that research has emphasized implementation and design over conceptual clarification, which has produced varied and sometimes interchangeable uses of the term. Van den Beemt, van de Watering, and Bots (2022), whose CBL Compass is the most systematic attempt to map variation in CBL practice, identify a "limited understanding of variety in CBL characteristics" (p. 25). The Compass is valuable, yet it describes implementations while leaving undefined the construct those implementations are meant to realize. What the CBL literature does say about challenges, which is more than its definitions suggest, is reported in Section 5.1.

2.2 Consequences

Theoretical. Without a definition, the relationship between challenge and learning is underspecified. CBL describes a process in which learners engage with a situation, investigate it, and act. However, a description of that process does not explain what makes the situation a challenge or why engaging with it should support learning. It is unclear whether challenge names the situation, a component of it, a relationship between the learner and the situation, or some combination. Each account carries different expectations about how and when learning occurs. If challenge is simply another name for an authentic, open-ended problem, its contribution must be explained through concepts that existing approaches already provide. If it names something more, that contribution needs to be stated before it can be investigated. A definition cannot on its own establish CBL as a distinct pedagogy, but it can set out the grounds on which claims of distinctiveness can be examined.

Practical. The same gap leaves educators without shared criteria for important design decisions. Selecting a situation, framing it for learners, judging its demands, deciding when to intervene, and assessing the response all depend on an account of what makes something a challenge. Without that account, practitioners can follow the same phases while designing very different learning experiences, or reproduce familiar problems and projects under a new name.

Accounts of implementation illustrate what is at stake. Kools and van Ravenswaaij (2023) discuss the need to support students through the uncertainty of open-ended challenges. Doulougeri et al. (2024) identify difficulties in refining challenges and applying theoretical knowledge within the available time. Martin and Bombaerts (2025) describe students spending more time negotiating what the challenge's project problem was than actually working on it. These difficulties do not in themselves show a definitional failure, since negotiating a focus and working through uncertainty can be productive parts of learning. The difficulty is that, without a clearer concept of challenge, educators have no shared basis for telling uncertainty that serves learning from uncertainty caused by poor framing or support.

Research. An undefined central construct also makes it hard to specify what is being studied. Researchers need criteria for identifying an experience as challenge-based, describing differences between implementations, and deciding which features might explain observed outcomes. Where these criteria remain implicit, studies using the same label may examine very different experiences, and studies using different labels may examine similar ones. Outcomes attributed to challenge may reflect features shared with problem- or project-based learning, features of a local implementation, or the way learners engage with the situation. Unless these possibilities are distinguished, research can document outcomes but has difficulty explaining their relationship to challenge. The variation mapped by van den Beemt et al. (2022)

makes this especially important. A shared definition would not require uniform implementation. It would provide a basis for describing variation, comparing findings, and testing claims about what challenge contributes to learning.

2.3 Four senses of challenge

The ambiguity concerns not only situations which count as challenges, but also what kind of things the word names. In CBL, challenge can refer to a statement, a learning unit, or a broader educational orientation. It is also used, less explicitly, for what learners accept or take on. We argue that moving between these senses without acknowledging the shift helps keeping the definitional gap open. The framework's materials name the first, third, and fourth senses. The second appears mainly in verbs, as when students are asked to "accept and solve challenges" (Nichols & Cator, 2008, p. 1), and in references to ownership. It is the sense the literature leaves least developed.

The first sense is the **challenge statement**, the actionable proposition formulated during Engage, the first phase of CBL (Nichols et al., 2016). "Make our school a place where every student belongs" is an example. A statement can be recorded, communicated, revised, and assessed for clarity. It is what educators are trained to create when they are asked to write a challenge. Implementations outside the Engage, Investigate, and Act structure, common in engineering, often present the challenge as a brief instead: a longer text, usually from an external partner, that sets out the situation, its context, and often the expected deliverable. A brief and a statement differ in form but play the same role, since each puts the situation into words for learners.

This sense has two functions. An initiating statement or brief opens inquiry, and a refined statement expresses learners' commitment as they take the situation on. How much refining is needed depends on where the initiating statement comes from. If learners create a challenge statement from a Big Idea, it is already theirs and may need little adjustment. If it is broad or comes from someone else, learners narrow it so that it connects to their context and to what they care about. When an external partner provides a detailed brief, the wording may stay the same, and refinement then consists in learners finding their own reasons for taking the situation on. Most refining happens during Engage, where it is normally the act through which the challenge comes into being. Learners may return to it during Investigate or Act if what they learn shows that the situation differs from the one they committed to, and each such revision can deepen their ownership. Most other changes during those phases belong to the response. Section 7.4 develops this account.

The second sense is challenge as **what learners take on**: a situation that a person or group accepts as their own and commits to responding to. The framework's materials point to this sense when they speak of accepting challenges or of learners taking ownership. However, they treat ownership as a feature of the process, as the passage below shows, and do not make it part of what a challenge is. A statement can invite learners to take a situation on without guaranteeing that they will, and learners can take a situation on without a written statement. The wording of a statement alone cannot establish its significance for learners, their willingness to take it on, or their capacity to respond. Whether this sense should anchor a definition is a question the analysis must answer. Sections 6 and 7 argue that it should, and that what it names is a relation between learners and a situation.

The third sense is the **challenge unit**, the bounded learning experience that organizes the work. The CBL User Guide described such units as scaling from nano to strategic (Nichols et al., 2016). Their form depends on the setting. In schools, a unit may be a project week or a term-long unit. In universities, it often matches a course, a module within one, or a whole semester. The unit is what practitioners usually mean when they speak of "running a challenge." A unit can include several statements and different learner relationships to the situations those statements frame. Calling something a challenge unit does not, on its own, establish that participants have taken on a challenge in the second sense.

The CBL User Guide shows how easily these senses run together:

"Standard Challenges are longer (one month and longer) and allow considerable latitude for the Learners. Working together, the Learners identify and investigate Big Ideas, develop Challenges, do extensive investigation across multiple disciplines and take full ownership of the process." (Nichols et al., 2016, p. 15)

In the first sentence, "Challenges" names learning units distinguished by duration and scope. In the second, "develop Challenges" appears to mean formulating statements within those units, while ownership is described as a feature of the process. The passage links the unit, the statement, and learner ownership without saying how they relate. It shows why these distinctions need attention within the framework's own guidance.

The fourth sense is **challenging as an orientation**, which extends beyond any single learning unit. The practitioner guidance distinguishes Challenge used as a noun from Challenge used as a verb (Challenge Institute, 2018). As a noun, Challenge is a finite event or series of events used for a particular purpose within a program. As a verb, to challenge something or someone, it is "a way of thinking" that informs institutional philosophy, organizes the curriculum, and shapes planning, organization, and teaching. We read this distinction as identifying an educational orientation alongside the bounded learning unit. We have not found it examined in the research literature. However, Dikilitaș et al. (2025b) note that the field has not settled whether CBL is an educational concept or a teaching method, a question the noun–verb distinction helps to explain.

Separating these senses clarifies what a definition and a shared vocabulary must do. A definition must say which sense it defines and what makes something a challenge in that sense. A vocabulary must keep the senses apart. Section 2.2 left open whether challenge names a situation, a component, or a relationship between learner and situation, and Sections 5 to 7 propose an answer. Together, a definition and a vocabulary provide a basis for addressing the theoretical, practical, and research difficulties identified in Section 2.2. Section 7.4 develops the relationships among the first three senses, Section 7.5 examines the fourth, and Section 7.6 proposes terms for all four.

3. Method

3.1 Conceptual framework analysis

This study uses conceptual framework analysis (Jabareen, 2009), supplemented by an etymological and corpus analysis of the word itself. Jabareen bases his notion of a concept on Deleuze and Guattari (1991), for whom a concept is made of components, is created, and responds to a problem. Here, the problem is the definitional gap described in Section 2. The design rests on a premise from discourse studies: the meaning of a concept is shaped by the contexts and communities in which it is used (van Dijk, 2011). This premise suits a term whose difficulty lies in carrying different meanings in different communities of practice. We adopt it as a premise and do not apply a discourse-analytic procedure.

Jabareen's method was preferred to Walker and Avant's (2019) concept analysis and to Nuopponen's (2010) systematic concept analysis for three reasons. It is designed for multidisciplinary concepts. It is systematic while leaving room for complex relations between concepts. And it accepts a wide range of data sources, societal as well as academic. The last point matters because some of the most instructive uses of "challenge" occur outside academia. From Walker and Avant, we keep one step, the identification of defining attributes, which we apply as a necessity test in phase three.

We used a modified version of Jabareen's eight phases, condensed into four and supplemented by the etymological and corpus analysis reported in Section 4. The data came from two bodies of literature. The CBL corpus extends the one assembled for our earlier literature survey (Perna et al., 2023), which drew on searches of Scopus and Web of Science. We updated it with more recent searches and with literature

mapping assisted by artificial intelligence (AI), using Elicit and OpenAlex searches combined with a large language model connected to OpenAlex,[2] followed by citation chaining.

The cross-domain corpus was assembled purposively. Within each of the nine domains identified for the analysis (see below in Section 3.2), we identified the most relevant and representative sources (Jabareen, 2009). We began with foundational and highly cited works and extended the search through citation chaining and sources found during the analysis. In keeping with the iterative character of the method, sources were added until no new components emerged. The mapping is therefore purposive and not exhaustive, a limitation discussed in Section 9.1. Section 3.2 gives more detail on how cross-domain sources were selected.

Phase one: mapping and filtering. Sources were mapped across the multidisciplinary literature, filtered according to the selection criteria (Section 3.2), and grouped by discipline, type, and domain. Preliminary features were extracted and relevant occurrences recorded.

Phase two: identification and deconstruction. Key concepts were identified through close reading, producing a list of possibly competing or contradictory concepts. These were broken down into components and organized along three dimensions. Jabareen (2009) uses these dimensions to describe the role each concept plays in a framework: ontological (what is assumed to exist), epistemological (how it can be known), and methodological (how the framework is put to work). We adapted them to the topic: ontological (what challenges are), epistemological (how challenges generate knowledge or learning), and methodological (how challenges are implemented or presented). This structure allowed systematic comparison across domains while preserving what was specific to each.

Phase three: integration and synthesis. Similar components were combined and contrasting components identified. Through repeated cycles of synthesis, the components were developed into a coherent framework and a proposed definition. A necessity test was applied at this stage. For each candidate component, we considered whether an experience missung it would still count as a challenge in the developmental sense the definition serves (Section 6.5). Components that passed were then examined for their logical role, which separated one constituting condition from the essential properties. The remaining components were kept as supporting features.

The resulting definition is stipulative, in the sense of what Carnap (1950) called an explication: a vague everyday term is replaced by a more exact one. An explication is judged by its similarity to ordinary use, its exactness, its usefulness, and its simplicity. Sections 4 and 5 document ordinary use, Section 6 seeks exactness, and Sections 7 and 8 argue for usefulness. This keeps the stipulation accountable. The definition remains a choice, as any definition of a contested term must be. However, the choice is constrained by existing usage and judged by what it allows educators and researchers to do, so it can be assessed and corrected.

Phase four: presentation and refinement. The emerging framework was presented to and discussed with scholars and practitioners in workshops, including at the 1st International Challenge Based Learning Conference in Eindhoven in April 2025, and refined in response. This phase is ongoing, and the framework remains open to further change.

3.2 Domain and source selection

Beyond the CBL literature, the analysis was extended to domains where “challenge” is a central organizing concept. This cross-domain approach was essential for two reasons. First, since CBL draws on diverse pedagogical and philosophical traditions, examining how challenge works in related contexts inside and outside education reveals both shared assumptions and distinctive features. Second, challenge has been theorized and operationalized in fields the CBL literature rarely engages, and these fields offer well-developed frameworks that can strengthen CBL’s conceptual foundation.

Domains were selected against four criteria:

1. the existence of developed theoretical frameworks that explicitly address challenge;
2. the centrality of the challenge concept to the sources' core arguments;
3. relevance to learning, development, or transformation; and
4. the potential to reveal blind spots in CBL discourse.

Nine domains met these criteria: problem- and project-based learning; adventure and outdoor education; psychology; sports and athletic performance; organizational psychology; engineering and technology; design thinking; public policy and governance; game design and digital culture. Reality television is added as an illustrative case. It does not meet the first criterion, and it was not used to derive components. Section 5.5 uses it to show that several senses of the word can coexist in one designed format and still be separated analytically.

Three types of source were distinguished. Primary conceptual sources explicitly define or analyze the concept of challenge. Implicit usage sources were included where "challenge" appeared often and in consistent patterns that reveal underlying assumptions. Corpus and lexicographic sources (the Oxford English Dictionary [OED], the Historical Thesaurus of the OED, the Google Books Ngram Viewer, and British National Corpus collocation data) were used for the etymological analysis. All sources needed sufficient depth for analysis, clear disciplinary placement, and verifiable authorship. Documents in which the term appeared only in passing, was used purely colloquially, or lacked enough context for interpretation were excluded.

Analysis began with an initial scan for explicit definitions, followed by close reading to identify implicit ideas about challenge. Conceptual components were then coded using both deductive categories (ontological, epistemological, methodological) and themes that emerged from the material. Components were compared across domains, combined into broader themes, and checked against the original sources.

4. Etymological and Corpus Foundations

Part of the reason the concept resists definition is that the meaning of the word has kept changing. This history explains why practitioners can use "challenge" with confidence and still mean incompatible things. It also shows that the growth-oriented sense CBL relies on is recent and historically contingent.

4.1 From accusation to opportunity

According to the Oxford English Dictionary, "challenge" derives from Middle English calenge, chalange < Old French calenge, chalenge, originally from Latin calumnia, meaning "trickery, artifice, misrepresentation, false accusation, malicious action at law." The OED notes that "challenge" is thus originally the same word as "calumny" (Oxford English Dictionary [OED], 2025).

The OED lists thirteen senses of the noun, developed across law, hunting, sport, medicine, and electronics. The older senses include accusation (sense 1), a claim as of right (sense 5), the sentry's demand for a password (sense 2.a), "a calling in question or disputing" (sense 4), and "an invitation or summons to a trial or contest of any kind; a defiance" (sense 6.a). The modern sense comes late: "in weakened use: a difficult or demanding task, esp. one seen as a test of one's abilities or character," first attested in 1954 (sense 6.b; OED, 2025, in an entry first published in 1889 and not yet fully revised).

This date matters, with a caveat. A first recorded use in an entry not yet fully revised cannot date the educational meaning precisely. Even so, the sense that educational discourse depends on, in which difficulty tests capacity and so becomes an occasion for growth, appears to be only about seventy years old. The OED classifies it as a weakened use of the older, confrontational sense.

Working from a different corpus, Martin and Membrillo-Hernández (2026) trace the same descent from calumnia, record the same classification of the modern sense as a weakened use, and date its general circulation to the postwar period. They add one element. Toynbee's A Study of History (1934) generalized challenge and response into a pattern of civilizational development. It kept the antagonistic structure of the older usage but made the challenger abstract, so that climate, terrain, or circumstance could issue a challenge. Section 7.3 draws on this pairing, and Section 8.5 on the difficulty it carries.

4.2 Corpus evidence

Google Books Ngram data (1500–2022) show a shift in grammatical form (Google Books Ngram Viewer, 2022). The verb dominated early modern English, accounting for about seven in ten uses between 1550 and 1650. This is consistent with the OED's record of challenge as an act of accusation or calling to account, although figures before 1800 should be read with caution because the early corpus is small. From the 1920s, and faster after 1950, the noun and the adjective "challenging" grew, and the noun overtook the verb around 1931. The verb also grew, but its share fell from about half of all uses before 1950 to about a third today.

We read this shift as a change in concept. An action performed on others became a condition that people encounter, so that a challenge became something one faces more often than something one issues. The plural "challenges" rose from about one in ten noun uses before 1960 to about half in the 2010s, and it pairs most often with meet, face, and address. With "the challenge," meet is the most frequent verb, followed by accept, face, and take up. With "a challenge," the most frequent verbs are pose and present, and their subject is usually a situation.

British National Corpus collocation data fit this picture (Just The Word, n.d.). Verbal uses divide between epistemic challenging (of assumptions, theories, views) and challenges to authority (of governments, validity, leadership). Verbs taking the noun as object fall into groups that create or present a challenge (mount, offer, present), engage with it (accept, enjoy, relish), confront it (face, meet), or start a contest (launch, throw down). The noun reaches the epistemic and political registers less often, mainly in uses such as legal or constitutional challenge.

4.3 Implications

The evidence shows that challenge is a highly polysemous term, meaning that it carries many related meanings. Over time it has gained meanings across registers and let a few fall out of use, most notably the narrow sense of accusation (Historical Thesaurus of the OED, 2025). That sense survives in weakened form wherever challenge means calling something into question, as in a legal challenge or a challenge to authority. Through these changes, the word has kept a stable core of associations with difficulty, confrontation, and testing. As a result, what it means in any given use depends heavily on context.

Several consequences follow for this study. First, the conflation of challenge with problem is a semantic inheritance and is not explained by carelessness. Both terms carry the sense of obstacle and difficulty, and the older meanings of "challenge" support that reading. This adds to the disciplinary inheritance noted in Section 2.1, where one of the framework's origins introduced the term as a replacement for "problem" (Baloian et al., 2006). The word came to CBL already carrying the association, and it was adopted in a way that reinforced it.

Second, any definition must be stipulative in the technical sense. Since no settled meaning exists to report, a definition must select among the meanings in use and be explicit about what it excludes. Third, and most important for CBL, the growth-oriented sense of challenge is the word's newest sense and, by the OED's classification, its weakest. It is not the default meaning. A framework built on that sense cannot rely on the word to carry the meaning by itself, and so it needs to define it.

Fourth, the verb matters. In the British National Corpus, verbal uses of "challenge" concentrate in two fields: the epistemic (one challenges assumptions, theories, or views) and the political (one challenges authority,

validity, or leadership). The noun reaches these fields less often. They are also the fields the framework draws on when it describes challenge as a verb, a way of thinking that runs through an institution. The shift from verb to noun documented in Section 4.2 is therefore also a shift away from critique. A field that speaks of challenges only as tasks leaves little room for the questioning of assumptions that the verb describes. Section 7.5 returns to this point.

A fifth consequence fits less comfortably with the argument of this paper. Martin and Membrillo-Hernández (2026) hold that problems presuppose resolution, projects presuppose realization, and challenges presuppose opposition. The first two claims are consistent with the account given here. The third is not, since the definition proposed in Section 7 contains no opposition.

The historical record shows that for most of its life the word carried an agonistic, or contest-based, structure, in which a challenger addressed someone before a forum able to judge the claim. The sense the OED records from 1954, which educational usage draws on, keeps part of this structure. It still names something one must answer, since the verbs it takes most often are meet, accept, face, and take up (Section 4.2). It has lost the antagonism, which is why the OED classifies it as a weakened use. It has also lost the identifiable challenger, since a challenge is now usually posed by a situation and not by a person. Section 7.3 argues that pairing challenge with response keeps the answering relation, and Section 8.5 considers whether losing the rest is a development to record or a depoliticization to resist.

5. Cross-Domain Analysis

We begin with the CBL literature, since its usage is what is in question, and then present nine further domains in four groups. The CBL literature is read for what it assumes and what it leaves out. The other domains provide a comparison that keeps the definition from simply restating CBL usage. For each domain, we ask three questions: what the domain takes a challenge to be, what work the term does there, and what the domain contributes to a definition or leaves out.

5.1 The CBL literature

The CBL literature is examined first, since its central concept is the one under study. The corpus is the one described in Section 3.1. As Section 2.1 showed, definitions in this literature treat the challenge as a kind of problem or describe the framework around it. More often, the literature describes challenges through recurring characteristics. Counting the terms for each characteristic across the 175 full-text sources gives a rough measure of how widely they are used:

- relevance to learners (159 sources);
- collaboration (152);
- action (144, a count dominated by the word solution);
- complexity and uncertainty (141);
- a real-world or authentic setting (135);
- multidisciplinarity (113); and
- stakeholders or partners (111).

Open-endedness, which the foundational texts use to describe challenges, appears in only 71 sources. These counts show how widely the vocabulary is used. They do not show that every source applies it to the challenge.

The literature also treats the challenge as the starting point of the work, and it describes action mostly through one word. Solution appears in 143 of the 175 sources, other action terms (actionable, call to action, concrete action) in 44, and problem in 153. In short, the literature describes challenges mostly in the vocabulary of problems and solutions. We read this as a fact about the field's vocabulary more than about its conceptual commitments.

What the literature leaves out is as informative as what it includes. Its characteristics describe the situation as real, uncertain, and open. None of them describes the fit between the situation's demands and the learner's capabilities, which most of the domains below treat as central (Sections 5.2 to 5.5 and 6.4). The closest is meaningfulness, which concerns the learner's interest in the situation and not how difficult it is for them. Learners often help formulate the challenge, but the literature does not treat their decision to take it on as part of what makes it a challenge.

The literature does, however, point to at least two features of challenges that a definition may need to accommodate. The first is structural. The CBL User Guide classified challenges into nano, mini, standard, and strategic levels, ranging from short, skill-focused experiences to extended, cross-disciplinary, or institutional initiatives (Nichols et al., 2016). Perna et al. (2023) identify comparable levels in their literature survey. Sung, Thomas, and Rikakis (2024) extend this structural view through the Challenge-Based Reflective Learning framework, which places challenges within repeated cycles of reflection and transformation. Whatever a challenge is, the units that contain challenges can be scaled and adapted.

The second feature concerns co-creation and partnership, meaning the different kinds of partnership between learners and the people who shape or take part in the challenge. A Practical Guide to Understanding and Implementing CBL (Dikilitaș et al., 2025a) emphasizes co-creation among learners and external partners. Höffken and Lazendic-Galloway (2024) report that starting from ill-defined, open challenges with external stakeholders allowed students to take ownership of the challenges they worked on, which students linked to higher motivation and deeper learning. What students connected to motivation was ownership, which concerns their relation to the challenge. Section 7.2 returns to this point.

The emphasis on partnership is also partly recent. In the engineering education literature, studies with external partners rose from about one in eleven before 2015 to more than three in four between 2019 and 2022 (Martin & Membrillo-Hernández, 2026). Partnership may therefore describe how CBL is often implemented more than what a challenge is, a question Section 6.5 takes up. In the co-creation view, the challenge is a designed mechanism that motivates inquiry, supports collaboration, and connects learning to purposeful action, which is more than an instructional prompt does. A mechanism that is scalable, co-created, and structured by reflection is poorly described as "a complex problem." These two findings, together with the characteristics described above, are carried into the cross-domain synthesis in Section 6.

5.2 Education beyond CBL

Problem- and project-based learning. The word "challenge" appears across the Problem (PBL) and Project (PjBL) traditions but is rarely defined. Classic PBL organizes learning around ill-structured problems intended to spark inquiry and self-directed learning (Barrows & Tamblyn, 1980; Savery, 2006). Foundational PjBL work anchors design in a driving question (Blumenfeld et al., 1991; Krajcik & Blumenfeld, 2005). In both, challenge serves mostly as a synonym for problem or driving question, or as a modifier that suggests difficulty, depth, or authenticity. More recent frameworks introduce a "Challenging Problem or Question" (Larmer, Mergendoller, & Boss, 2015). The phrase signals openness and sustained inquiry, qualities long present in strong PjBL and PBL design (Bell, 2010), but it does not say how learners experience tension, motivation, or growth through difficulty.

An early exception is Meyer, Turner, and Spencer's (1997) study of "challenge seekers" and "challenge avoiders" in project-based mathematics, which treats challenge as something learners experience. Otherwise, the term is widely used and rarely examined. Strong PjBL practice attends closely to how learners engage, and current project design frameworks include student voice and choice, reflection, and critique and revision (Larmer et al., 2015). What these traditions have not done is theorize challenge itself. Where the word appears, it is mostly contextual, a description of the task. It could also be treated as experiential, something that shapes the learner's engagement. This distinction is central to our argument.

Adventure and outdoor education. In these traditions, challenge is central. They hold that people learn most deeply when they move beyond what is familiar, provided they feel supported throughout.

The tradition's main contribution is challenge by choice. The idea emerged from Project Adventure and has been widely adopted in adventure education (Priest & Gass, 2018; Rohnke, 1989). It holds that educators invite learners into physical, social, and emotional challenges, while the learners decide how far to go. This balance of encouragement, risk, and agency presents challenges as opportunities, so that learners take part willingly and without coercion.

Among the educational traditions examined here, adventure education states the choice condition, which we later call volition, most directly.

Experiential education theory explains how this works. Kolb (1984) argued that learning requires disruption, meaning situations that unsettle habits and assumptions and call for reflection and adaptation. Outdoor and adventure educators put this into practice through ropes courses, wilderness expeditions, and group problem-solving activities that deliberately include risk and uncertainty (Neill, 2008). What matters is less the tasks themselves than the way they require learners to face discomfort, collaborate, and develop creative responses under pressure.

The tradition also attends to the degree of challenge as the learner experiences it. It describes this as a balance between risk and competence (Martin & Priest, 1986; Priest & Gass, 2018). The more common practitioner version uses zones (Luckner & Nadler, 1997): too little demand leads to disengagement, too much leads to panic, and the stretch zone in between creates the conditions for growth. Importantly, the experienced degree of challenge is subjective. The same ropes course may feel exciting to one learner and overwhelming to another, and practices such as challenge by choice allow for this variation. Section 7.2 develops this idea into a measure of how fully a situation that learners have taken on shows the properties of a challenge.

The Outward Bound movement developed this understanding further. Kurt Hahn co-founded it on the premise that development occurs through responsibility, service, and challenge (James, 2000). Its programs were built around what Walsh and Golins (1976) call adaptive dissonance, a productive imbalance in which learners leave familiar environments, meet demanding tasks presented in increasing but manageable steps, and receive help in making sense of the experience. Practitioners plan this progression as the sequencing of activities (Prouty, Panicucci, & Collinson, 2007), often as an "adventure wave" of rising and falling intensity (Schoel, Prouty, & Radcliffe, 1988). We call the resulting pattern an arc of challenge.

Research supports programs designed around this arc. A meta-analysis of adventure programs found immediate gains in outcomes such as self-concept, locus of control, and leadership. Unusually, it also found further gains between the end of the program and follow-up, with effects increasing with program length and participant age (Hattie, Marsh, Neill, & Richards, 1997). Neill (2008) reports small to moderate effects and notes that theory in the field remains largely ad hoc. The field's working assumption, expressed in the stretch-zone model (Luckner & Nadler, 1997), is that results are strongest at a "sweet spot" of challenge that is difficult but achievable. Testing this assumption remains an open question.

Adventure education therefore contributes three ideas to the definition. The first is one of the most developed account of choice. The second is calibration as the educator's central design task. The third is the recognition that challenge lies in the learner's relation to a task, where problem- and project-based learning frameworks have mostly described it as a feature of the task.

5.3 Human development sciences

Psychology: challenge versus threat. The biopsychosocial model (Blascovich, 2008; Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996) distinguishes two states by cognitive appraisal, that is, by how a person judges the situation. A challenge state arises when perceived resources are sufficient for the demands, and a threat state arises when the demands exceed them. Challenge is associated with a more efficient cardiovascular pattern and typically with better performance. Threat is associated with a less efficient pattern and a focus on avoiding loss, although both involve engagement with the task (Seery, 2011).

This literature defines challenge mainly by contrast with threat and says little about what it means to the person who experiences it. Even so, the distinction offers the most important insight in the corpus. Challenge depends on how people perceive their capacity in relation to the difficulty, and the presence of difficulty alone establishes nothing. A challenge state is a way of meeting pressure with agency when avoidance was also possible. This makes challenge less about the task and more about how a person approaches it.

This finding has a direct and often overlooked consequence for education. If challenge and threat are distinguished by appraisal, and objective demand does not decide which one arises, then the same designed experience can be a challenge for one learner and a threat for another. A curriculum document can specify demands, but it cannot specify how particular learners will weigh those demands against their resources. Whether a design is a challenge therefore depends on who meets it. What a document can contain is a design that makes challenge likely for the learners it is meant for (Sections 7.4 and 8.1).

Sport and athletic performance. The Theory of Challenge and Threat States in Athletes (TCTSA; Jones et al., 2009) extends the psychological account with unusual precision. A challenge state emerges when athletes judge a situation to be difficult but manageable, with skills, confidence, and coping strategies sufficient for the demands. Effort then feels directed and attention widens. When the same demands seem overwhelming, energy drops, anxiety breaks up attention, and the moment comes to feel like danger instead of opportunity (Blascovich & Mendes, 2000; Jones et al., 2009). In this account, challenge is an interpretation of the moment and is not fixed.

Motivational theory connects directly to this account. Csikszentmihalyi (1990) described flow as the state in which challenge and skill are balanced. Self-Determination Theory (Deci & Ryan, 1985) adds that challenge supports intrinsic motivation and ownership when it allows people to feel competent and capable. Good coaching follows the same principle, setting conditions that stretch athletes without overwhelming them and that encourage growth instead of fear. Challenge then becomes a design tool, a way to shape experience toward mastery and meaning (Vallerand & Blanchard, 2000).

Research on deliberate practice points in the same direction. Expertise develops through effortful activities that target performance just beyond the current level (Ericsson, Krampe, & Tesch-Römer, 1993), although a replication found the effect to be considerably smaller than first reported (Macnamara & Maitra, 2019). Challenge states have been associated with better performance under pressure (Hase et al., 2019; Moore et al., 2012). The sharp division between challenge and threat has also been questioned, since an athlete may appraise a situation as both (Meijen et al., 2020; Uphill et al., 2019).

Sport and motivational research therefore add four points. They confirm the appraisal account where performance can be measured. They show that the resources people weigh include confidence and coping as well as skill. They place productive difficulty just beyond current capability, on moderate evidence. And they show that the boundary the definition draws is a tendency in appraisal more than a switch (Section 7.3).

Organizational psychology. The challenge–hindrance stressor framework offers the most explicit definition of challenge as a category of demand in our corpus, together with a widely used measure. Cavanaugh et al. (2000) defined challenge stressors as “work-related demands or circumstances that, although potentially stressful, have associated potential gains for individuals” (p. 68). Hindrance stressors, by contrast, constrain personal development and performance. This framing changed how work stress was understood. Stress was no longer seen as uniformly negative, and it could produce positive outcomes when properly appraised and supported.

Meta-analytic work supported the distinction. Challenge stressors such as time pressure, workload, and responsibility improve performance directly and through motivation, although strain offsets part of the gain, while hindrance stressors harm performance throughout (LePine, Podsakoff, & LePine, 2005). Later work found that challenge stressors are sometimes appraised as hindrances and show their benefits less

consistently (Podsakoff, Freiburger, Podsakoff, & Rosen, 2023), and that challenge, hindrance, and threat are distinct appraisals (Tuckey, Searle, Boyd, Winefield, & Winefield, 2015).

The organizational literature therefore offers what the educational literature lacks: a fully operationalized construct of challenge. Its empirical support is mixed, and it comes with an important caveat. As first framed, the construct classifies demands, so that time pressure counts as a challenge whoever meets it. Later work shows that the classification depends on how workers appraise those demands. Even here, then, challenge behaves as a relational construct, and we will argue that this relational quality is what makes it part of the definition.

5.4 Design and engineering

Engineering and technology. Challenge is common in engineering discourse but inconsistently theorized. Societal problems are framed as challenges that call for innovative, solution-oriented responses, as in the fourteen Grand Challenges for Engineering announced in 2008 (National Academy of Engineering, 2008). In this usage, challenge works mainly as a rhetorical and motivational device. It signals ambition and complexity but does little analytical work (Kaldewey, 2018), and the framework tends to favor technical solutions over the human contexts in which they operate (Herkert & Banks, 2012). Calls for holistic engineering education widen the frame to include systems thinking, sustainability, and communication (Grasso & Burkins, 2010). A recent study treats a Grand Challenge as a challenge-based intervention and reports mixed effects on students' resilience (Vadapalli et al., 2024).

Engineering's contribution is limited but real. It associates challenge with scale and complexity, it aims to integrate knowledge across disciplines, and, in its sociotechnical strand, it attends to the real contexts in which engineering work matters (Lucena et al., 2008).

Design thinking. Design thinking is closely connected to engineering practice and gives more weight to framing a problem as part of solving it. Here, challenge names a problem that requires action and provides a provisional frame for inquiry into people's needs, assumptions, and possible solutions. The familiar "How might we…?" question turns a statement of what is lacking into a hopeful question that encourages imagination and collaboration (IDEO.org, 2015, pp. 85–86; Kelley & Kelley, 2013).

This reframing changes less than it seems. Practitioner toolkits typically begin with a problem (IDEO.org, 2015, p. 32), although Brown (2008) described the starting point as "a problem, an opportunity, or both" (p. 88), and design research shows problem and solution being reframed together (Dorst & Cross, 2001). The "How might we" question reformulates the problem while staying within it, and the process moves toward a product, prototype, service, or system judged by its impact on the people it serves (IDEO.org, 2015, p. 152). In the toolkit version, the challenge is bounded by the problem that starts it and the deliverable that completes it. Within those bounds, design thinking offers one of the most sophisticated accounts of framing in our corpus, treating constraints as productive and difficulty as a source of insight (IDEO.org, 2015, pp. 24, 32; Liedtka & Ogilvie, 2020).

The two neighboring fields are closer than their vocabularies suggest. Engineering uses challenge to name scale, and design thinking uses it to name a problem held open for investigation, but both run from a problem to a solution. Neither treats the development of the person doing the work as the aim of a given project. Both attend to it elsewhere: engineering education studies how engineers are formed (Stevens et al., 2008), and design education builds creative confidence through small challenges set in succession (Kelley & Kelley, 2013). In client work, the deliverable remains the aim.

This matters for CBL, whose language of opportunity resembles the generative vocabulary of design thinking and whose implementations sometimes borrow its tools. Those tools bring their structure with them, placing a problem at the start and a solution at the end, and CBL's own definitions, which describe challenges as problems, offer no counterweight. The gap between how CBL talks about challenges and how it defines them may contribute to the practical difficulties described in Section 2.2.

5.5 Societal and cultural domains

Public policy and governance. The term carries rhetorical weight across the public policy and management literature but has little conceptual precision. This literature works with grand challenges, which it defines in several inconsistent ways (Seelos, Mair, & Traeger, 2023). George et al. (2016) describe them as "formulations of global problems that can be plausibly addressed through coordinated and collaborative effort" (p. 1880). Ferraro, Etzion, and Gehman (2015) describe them as "seemingly intractable" problems marked by complexity, uncertainty, and evaluativeness, the last meaning that competing values shape how both problems and solutions are defined (p. 365). In this literature, challenge works as a mobilizing concept and a framing device that keeps dialogue open. It does little work as a classification.

Recent studies identify drift in how the term is applied. It is used as a broad signal of ambition (Seelos et al., 2023) and as a flexible term in communication with funders and partners (Välikangas, 2022). Seelos et al. (2023) warn against "language games" (p. 253) and propose retiring the concept. Others defend it as a way of mobilizing collective attention (Ferraro et al., 2015; George et al., 2016), even as "a prerequisite for mobilizing collective action" (Drori et al., 2025, p. 2).

This debate offers a warning for CBL. In a neighboring field, a central term came close to being retired as an analytical concept because its use had outgrown its definition. Definitional work in education helps keep a construct from becoming a slogan.

Game design. In game studies, challenge is commonly defined as the designed tension between a player's abilities and the demands of a task, calibrated to be neither trivial nor impossible. Players report several kinds of challenge: performative, cognitive, emotional, and decision-making (Denisova, Cairns, Guckelsberger, & Zendle, 2020). Work on flow (Csikszentmihalyi, 1990; Sherry, 2004; Sweetser & Wyeth, 2005) presents challenge as a condition for optimal engagement when perceived difficulty matches perceived skill. However, meta-analytic evidence finds this balance only moderately related to flow, and more weakly in education (Fong et al., 2015). Motivation research links challenge to intrinsic motivation through the need for competence (Malone & Lepper, 1987; Przybylski, Rigby, & Ryan, 2010; Ryan, Rigby, & Przybylski, 2006), and some authors stress the productive role of failure (Juul, 2013). Beneath all of this lies an assumption the field rarely states: people enter play freely, and the obstacles a game sets are ones players have chosen to face (Suits, 1978).

Design scholarship identifies several ways to implement and adjust challenge. These include scaffolding and progression (Gee, 2003; Sweetser & Wyeth, 2005), feedback that turns setbacks into useful signals (Przybylski et al., 2010), and dynamic difficulty adjustment, which adapts demands to player performance (Hunicke, 2005). Evidence on challenge and immersion is limited and mixed (Cox, Cairns, Shah, & Carroll, 2012; Nacke & Lindley, 2008).

Evidence on individual differences broadly supports a relational view, though not uniformly, and one finding deserves particular attention in education. Enjoyment depends on what the player brings as well as on the game (Vorderer, Klimmt, & Ritterfeld, 2004), so the same challenge can be meaningful for one player and exclusionary for another. Game design has built this recognition into practice through difficulty settings, assist modes, and dynamic adjustment. In this respect, it has arguably addressed the equity implications of calibrated difficulty more directly than education has. Overall, the literature treats challenge as a relational property that can be designed. It emerges from the fit among task demands, participant capabilities, and feedback, and a fixed measure of difficulty does not account for it.

Digital culture and media. The "challenge" has become a defining genre of social media, from the cinnamon challenge (Grant-Alfieri, Schaechter, & Lipshultz, 2013) to the Ice Bucket Challenge of 2014. It works as a template for participation more than as a single event. Viral formats spread because they offer structured opportunities for imitation and variation (Burgess, 2008), within a participatory culture in which people create and share content as well as consume it (Jenkins, 2006). Taking part signals membership in the group that has already done so.

The psychology of these formats is also instructive. Suits (1978) defined playing a game as "the voluntary attempt to overcome unnecessary obstacles" (p. 41), and McGonigal (2011) extends the idea to the challenges of everyday life. Digital culture carries this voluntariness into public participation, where both the obstacle and the choice to face it are visible. Many viral challenges require little skill and are completed for style or humor, so that the act feels personal while remaining public and countable (Marwick, 2013). The same patterns of invitation, repetition, and visibility can push participation toward recklessness, as the pursuit of recognition overrides judgment (Grant-Alfieri et al., 2013). The decision to join may feel voluntary, yet imitation and the wish to belong shape it strongly (Abidin, 2020; Marwick, 2013). This is a caution for designers who assume that offering choice ensures genuine volition.

From an anthropological perspective, viral challenges resemble what Turner (1974) called liminoid phenomena. These are voluntary, leisure-based counterparts of rites of passage that suspend everyday roles and draw participants into a temporary sense of community, which Turner called communitas (Turner, 1969). The community a challenge creates is part of its appeal. Taking a challenge on alongside others can turn individuals into a group. The definition reflects this by allowing a group to be the party that takes a challenge on (Section 7.1), and Section 7.2 connects it to relatedness. The same pull also makes choice fragile, since a challenge that draws people into a community also makes staying out costly.

Digital culture therefore confirms that voluntariness is part of what makes a challenge, shows how easily it can be imitated, and suggests that challenges taken on together can build the relationships that sustain them.

Reality television. Reality television offers a final perspective. It is useful because it displays a wide range of the term's meanings in a single format. Format studies describe reality tv shows as built on a repeating cycle of challenge, evaluation, and elimination (Murray & Ouellette, 2009). This rhythm builds suspense while bringing hidden skills to the surface and making them comparable through performance and judgment (Hill, 2014). In cooking competitions, a single challenge works at once as:

- a task (the assignment to complete);
- a trial (a means of evaluation, as in the "technical challenge");
- an obstacle (a surprise constraint);
- an opportunity (a chance to show creativity, identity, or resilience); and
- a narrative device (the turning point of the story).

Reality television is an illustrative case and was not used to derive components (Section 3.2). It shows that these five uses can coexist in a single designed experience and still be separated analytically. They are uses of the word within one format and are different from the four senses set out in Section 2.3.

Across these domains, each contributes a distinct emphasis. Psychology contributes mechanism, game design contributes calibration technique, and adventure education contributes the ethics of choice. Organizational psychology contributes the largest body of empirical tests, policy contributes a warning about definitional drift, and media contributes evidence of the term's cultural reach (Sections 5.2 to 5.5).

6. Component Analysis

Following Jabareen (2009), we broke the domain analyses down into conceptual components organized along three dimensions. This section presents the components, identifies patterns across domains, and then applies the necessity test that shapes the definition in Section 7.

6.1 Ontological components: what challenges are

Each component below states what the domains attribute to challenge. Section 6.5 tests which of them are necessary for our context.

Indeterminacy. A challenge is indeterminate. Its outcome is not predetermined, and typically more than one valid approach exists. This appears as ill-definedness in PBL (Barrows & Tamblyn, 1980), open-endedness in CBL (Section 5.1), uncertainty in the grand challenges literature (Ferraro et al., 2015), and the productive uncertainty of failure in game design (Juul, 2013). Indeterminacy is what separates a challenge from a task with a known method.

Authenticity. A challenge is authentic. It is set in a genuine context, with meaningful stakes and often with real stakeholders. This component is strongest in CBL (Section 5.1) and in the sociotechnical engineering literature (Grasso & Burkins, 2010; Lucena et al., 2008). Adventure education covers the full range. A wilderness expedition carries real consequences for the group's safety and well-being, while a ropes course or group activity sets its stakes within a constructed frame (Neill, 2008). Game design sits at the constructed end, although players still experience the stakes as real. These cases show that stakes can be felt within a constructed frame. The educational definition adds a condition: something beyond the exercise must depend on the learners' response (Section 7.1).

Relationality. A challenge is relational. It lies in the fit between a situation's demands and an actor's capabilities as the actor judges them, and no property of the situation alone accounts for it. This is the most consistent finding across domains. It is the core claim of the biopsychosocial model (Blascovich & Mendes, 2000) and the central mechanism of the TCTSA (Jones et al., 2009). It is also the recurring qualification in organizational psychology (Podsakoff et al., 2023), the explicit design premise of game design (Hunicke, 2005; Sweetser & Wyeth, 2005), and the basis of adventure education's models of risk and competence and of comfort, stretch, and panic zones (Luckner & Nadler, 1997; Martin & Priest, 1986).

Growth orientation. A challenge is oriented toward growth. It is taken on for the development it makes possible as well as for its result, and it looks forward to what is possible. This is explicit in the challenge–hindrance distinction (Cavanaugh et al., 2000) and in adventure education's view of risk as developmental. Design thinking's reframing (Brown, 2008) is a qualified case. The "How might we" question turns a statement of need toward possibility, but the reframing concerns the response and makes no commitment to the development of the people doing the work. Growth orientation therefore comes in degrees. A domain may use the language of possibility when framing the work while the work itself remains aimed only at its result.

Boundedness. The experiences that contain challenges are bounded, with an identifiable beginning and end. This is true in all domains, although at very different scales, from the minutes of a viral challenge to the multi-year programs organized around a grand challenge (Section 5.5). In CBL, it takes the form of the challenge unit, which has a finite span and varies in scale (Challenge Institute, 2018; Nichols et al., 2016). The challenge itself may outlast the unit (Section 7.4).

Volition. A challenge is voluntary: a person or group takes it on by choice and as their own. Choice is the premise of challenge by choice in adventure education (Priest & Gass, 2018; Rohnke, 1989) and of the account of game playing as "the voluntary attempt to overcome unnecessary obstacles" (Suits, 1978, p. 41; see also McGonigal, 2011), which digital culture's challenge formats extend to public participation. The same formats show the limit of choice alone, since social pressure can make a nominally free choice compulsory in practice (Section 5.5). In such cases people may choose to take part without the undertaking becoming their own. The CBL literature names explicitly this ownership and links it to motivation (Höffken & Lazendic-Galloway, 2024; Section 5.1), and self-determination theory treats it as autonomy, the experience of "self-endorsement and ownership" of one's actions (Ryan & Deci, 2017, p. 86; Section 5.3). The analyzed domains diverge on this component more than on any other (Section 6.4).

6.2 Epistemological components: how challenges generate learning

Action orientation. A challenge leads to action. This component attributes two things to it. Those who take it on act on the situation, which separates a challenge from an inquiry that ends in understanding (Section 7.1). And the learning it generates comes through that action, so that knowledge comes from doing. The

component is central to CBL's Act phase (Nichols et al., 2016), to experiential learning (Kolb, 1984) and to design thinking (IDEO.org, 2015).

Appraisal as an epistemic act. In a challenge, learning depends on appraisal. How learners interpret the situation shapes what they pay attention to and how they engage. The biopsychosocial model (Blascovich & Mendes, 2000), the TCTSA (Jones et al., 2009), and research on how workers appraise challenge, hindrance, and threat (Tuckey et al., 2015) all show appraisal shaping effort, attention, and performance. The consequence we draw for knowledge is that what is learned depends as much on how the situation is judged as on what it contains.

Productive disequilibrium. In a challenge, learning proceeds through disequilibrium, as existing habits and assumptions are unsettled and then rebuilt. Dewey (1938b) describes inquiry as the transformation of an indeterminate situation into a determinate one. Experiential learning theory provides a cycle for this process (Kolb, 1984), and the Outward Bound process names the mechanism adaptive dissonance (Walsh & Golins, 1976). This component explains why a challenge must stretch learners as well as engage them.

Calibrated difficulty. In a challenge, learning occurs at the edge of current capability. Adventure education calls this the stretch zone (Luckner & Nadler, 1997; Priest & Gass, 2018), flow theory the balance of challenge and skill (Csikszentmihalyi, 1990), and deliberate practice the level just beyond current performance (Ericsson et al., 1993). Where the domains have tested it, the evidence is moderate (Fong et al., 2015; Macnamara & Maitra, 2019).

Integration across boundaries. In a challenge, learning brings together knowledge from different disciplines, since challenges do not fit within a single discipline. This component appears in the CBL literature (Höffken & Lazendic-Galloway, 2024; Sung et al., 2024; Section 5.1) and in the interdisciplinary aims of the Grand Challenges for Engineering (National Academy of Engineering, 2008).

Reflection as integral. In a challenge, reflection is how the experience becomes learning. It is more than an activity added afterward. Reflection is central to experiential learning (Kolb, 1984), to the Outward Bound process, which ends by reorganizing the meaning of the experience (Walsh & Golins, 1976), and to the Challenge-Based Reflective Learning framework (Sung et al., 2024).

6.3 Methodological components: how challenges are implemented

Framed rather than found. The design frames the occasion. In the domains that design challenges, what is offered as a challenge is created through an act of framing by an educator, a partner, or the learners themselves. Even grand challenges, which name conditions that already exist, are presented as challenges through such an act (Ferraro et al., 2015; George et al., 2016), and design thinking makes framing an explicit step (IDEO.org, 2015). Section 8.5 asks who performs this act, and Section 7.4 asks whether anyone takes the framed situation on.

Scalability. The design sets the scale. Challenge units vary in scope and duration, and the CBL User Guide classified them from nano to strategic (Nichols et al., 2016; Perna et al., 2023). This is the design side of boundedness (Section 6.1): every unit has limits, and the design decides how wide they are.

Choice architecture. The design specifies what is chosen and by whom: how far to take part, how to investigate, how to respond, and what the challenge will be. This component is most developed in adventure education's challenge by choice (Priest & Gass, 2018; Rohnke, 1989). It is the design side of volition (Section 6.1).

Difficulty regulation. The design regulates difficulty by adjusting demands and support, either in advance or as the work proceeds, in response to participant performance. Game design does this through dynamic difficulty adjustment (Hunicke, 2005), and adventure education through the sequencing of activities (Prouty et al., 2007). This is the design side of calibrated difficulty (Section 6.2).

Feedback systems. The design provides feedback, turning setbacks into useful signals that suggest ways to improve (Przybylski et al., 2010). This mechanism is most developed in game design (Section 5.5).

Stakeholder integration. The design involves stakeholders, with external partners taking part in defining or receiving the work. This is characteristic of CBL (Dikilitaș et al., 2025a; Höffken & Lazendic-Galloway, 2024) and of the grand challenges literature, which defines grand challenges by the coordinated effort of many actors (George et al., 2016). In engineering CBL, partners became the main source of challenges only in the framework's recent history (Section 1).

Collaborative structure. The design organizes collaboration, since challenges are typically, though not always, taken on with others. Collaboration is among the most common characteristics in the CBL literature (Section 5.1). It is also central to the group activities of adventure education (Neill, 2008) and to the participatory formats of digital culture (Jenkins, 2006).

6.4 Cross-domain patterns

Five patterns recur consistently enough to be treated as findings in their own right.

First, **resource–demand balance** appears in every domain that theorizes how people experience challenge. Psychology calls it appraisal (Blascovich & Mendes, 2000), sport calls it challenge and threat states (Jones et al., 2009), game design calls it challenge–skill balance (Sweetser & Wyeth, 2005), and adventure education calls it the stretch zone (Luckner & Nadler, 1997). Organizational psychology reaches it through the appraisal of challenge and hindrance demands (Podsakoff et al., 2023; Tuckey et al., 2015). Several of these literatures use the word for the demand itself. What they share is the claim that the fit matters. The agreement of five literatures on a single structural claim is the strongest evidence in this study.

The five are not fully independent. Psychology, sport, and organizational psychology share a root in the appraisal theory of stress (Lazarus & Folkman, 1984), which the biopsychosocial model, the TCTSA, and the challenge–hindrance framework all draw on (Blascovich & Mendes, 2000; Jones et al., 2009; LePine et al., 2005). Game design, however, reached the same claim largely through flow theory (Csikszentmihalyi, 1990), and adventure education reached it through models of risk and competence (Martin & Priest, 1986). A related agreement concerns indeterminacy: problem-based learning, CBL, game design, and the grand challenges literature all treat an outcome that is not predetermined as part of what makes something a challenge (Section 6.1).

Second, **appraisal** is decisive. It is the mechanism that judges the balance described in the first pattern. In every domain that examines this mechanism, the same objective demand produces challenge or threat depending on how the person judges their resources (Blascovich & Mendes, 2000; Jones et al., 2009; Tuckey et al., 2015). Design can therefore make challenge likely, and any attempt to specify challenge as a fully designed object misunderstands what is being designed.

Third, **growth orientation** consistently separates challenge from related concepts. Where domains distinguish challenge from something else, whether hindrance, problem, or simple difficulty, the criterion is whether engagement is oriented toward development (Cavanaugh et al., 2000; LePine et al., 2005; Walsh & Golins, 1976). Threat is the exception, since it is separated from challenge by the appraisal of resources against demands, as in the first two patterns. The domains without this criterion make the same point from the other side. Engineering and design thinking move from a problem to a solution (IDEO.org, 2015; National Academy of Engineering, 2008). Neither treats the effect of the work on the person doing it as the aim of a given project (Section 5.4), which is also why neither can distinguish a challenge from a well-specified problem.

Fourth, the domains differ sharply on **volition**. Adventure education and digital culture make choice central (McGonigal, 2011; Priest & Gass, 2018; Rohnke, 1989). Game design assumes it, since play is voluntary by definition (Suits, 1978). Engineering and policy do not address it (Sections 5.4 and 5.5). Organizational

psychology sits between the two, since its challenge stressors carry potential gains for individuals but are not chosen (Cavanaugh et al., 2000; Podsakoff et al., 2023). Adventure education and game studies require volition. Organizational psychology shows developmental demands without it. We follow the first group, and this is a choice. CBL asks learners to pursue challenges as their own. It describes itself as learner-driven and its learners as taking ownership of the process (Dikilitaș et al., 2025a; Nichols et al., 2016), which places it with the first group.

Fifth, the domains divide on stakes. CBL, the sociotechnical engineering literature, and the grand challenges literature locate challenge in situations whose outcome matters beyond the activity (George et al., 2016; Grasso & Burkins, 2010; Lucena et al., 2008). Adventure education and game design show that challenge can also be experienced within a constructed frame, where the stakes are felt but nothing beyond the exercise depends on the result (Juul, 2013; Neill, 2008). This division parallels the one on volition, and which side a definition takes depends on what it is for. Section 6.5 takes the side CBL requires.

6.5 From components to properties

Sections 6.1 to 6.3 describe challenge through nineteen components. A definition needs fewer, so the next step reduces and filters them. This corresponds to the integration step of Jabareen's (2009) method, in which similar components are merged and their number reduced. It also serves the exactness and simplicity that an explication requires (Section 3.1).

To decide which components to keep, we applied a necessity test. For each component, we asked whether an experience lacking it would still count as a challenge in the developmental sense that this definition serves. Section 5 shows that the word is used more widely than that sense allows. A ropes course with nothing at stake beyond the exercise, a televised baking round with a set recipe and a known product, a job demand no one chose, and a viral dare taken up for recognition are all called challenges. The test therefore asks what CBL needs the word to mean. An explication may set such uses aside, provided it stays recognizably close to ordinary use and justifies its narrower sense through what it allows educators and researchers to do (Carnap, 1950).

Six components pass the test, and they combine into four elements of the definition, on two kinds of grounds. Productive complexity rests mainly on evidence. It combines three components: indeterminacy and relationality from Section 6.1 and calibrated difficulty from Section 6.2. The combination is justified by what the three exclude together. Without indeterminacy, an experience is a task with a known method and a predetermined outcome. Without calibration, its demands either fall within present capability, so that responding need not require learners to extend their capabilities, or exceed perceived resources and tend toward threat, although the two appraisals can occur together (Section 7.3). Relationality is how calibration works, since learners judge the fit. The property therefore sets a boundary on each side. The definition states its two aspects, indeterminacy and calibration, in separate clauses since they can vary independently.

The fit between demands and perceived resources is the best-supported result of the study, resting on the agreement described in the first two patterns of Section 6.4. The lower limit, that demands should exceed present capability, has more modest support (Section 6.2) and is adopted as a requirement of the developmental definition. Consolidation, transfer, judgment, and reflective understanding can also develop through work learners can already do. Indeterminacy rests on the agreement noted with the first pattern, and it is also the aspect that separates CBL's sense from uses such as the televised technical round.

The other three components are commitments of the developmental sense, which the evidence supports but does not require. The domains show that growth orientation distinguishes challenge from related concepts (Section 6.4). Making it necessary is the commitment, since growth orientation is the developmental sense itself and could not fail a test framed in its terms. What the domains provide is its content. They contrast it with hindrance, where demands obstruct without offering gain, and with problems, which identify a difficulty to be addressed and say nothing about the development of the people who address it.

Volition is required by those domains, adventure education and game studies, that treat challenge as something a person pursues for their own development, the group with which CBL belongs (Section 6.4). It is absent from organizational psychology, where challenge stressors carry potential gains for individuals but may be imposed (Cavanaugh et al., 2000). That literature shows growth orientation without volition, and a compulsory demand with developmental potential is what Section 7.2 calls an assignment.

Real-world significance is the commitment most specific to CBL. The fifth pattern shows that the domains divide on stakes, and that ropes courses and games can be challenges with nothing at stake beyond them (Section 6.4). The definition sets those cases aside because CBL asks learners to address situations whose outcome matters to someone. Its final clause names this purpose as the difference their response makes. Including these three components is a stipulation in the sense of Section 3.1.

The four elements do not, however, play the same role, and treating them as a simple list hides the difference. Significance, complexity, and growth orientation are properties. Each is necessary. An experience that lacks any one of them is not a challenge in the sense defined here, while one that has each, however weakly, is a challenge low in challengeness. Above that minimum, an experience has each property to a greater or lesser degree, so one can ask how much of each a given experience has. Where the minimum lies in practice is a matter for further work (Section 8.3).

Volition works differently. It is the act by which a situation becomes a challenge for someone in the first place, and it sits beneath the features a challenge shows. A situation may be significant, complex, and developmental in every respect and still not be a challenge until somebody takes it on. Once somebody does, it is a challenge for them and for no one who did not. We therefore call volition the constituting condition and the other three the essential properties.

This distinction is useful in two ways. First, volition can only be established by reference to a person, while the three properties are relational to different degrees: productive complexity depends on the learner's appraisal, significance is always significance to someone, and growth orientation depends on what those involved understand the work to be for, which framing can encourage. Second, it prepares the relational argument of Section 8.1.

Action orientation does not appear as a separate property, because the action it names (Section 6.2) is part of the constituting act, in which a learner takes a situation on and commits to a response (Section 7.1).

The remaining components fail the test but are not discarded. Collaboration, stakeholder integration, scalability, boundedness, reflection, feedback, integration across boundaries, and productive disequilibrium are supporting features. They are characteristic, often desirable, and sometimes defining of good practice, but they are not essential. A challenge taken on alone is still a challenge, and so is a challenge with no external partner. Productive disequilibrium describes how learning often proceeds in a challenge, but a challenge can stretch learners without unsettling their assumptions.

This distinction between essential properties and supporting features is itself a contribution. Much CBL practice treats some supporting features, external partnership in particular, as requirements, and so narrows the construct unnecessarily.

The remaining four components are of a different kind. Framed rather than found, choice architecture, and difficulty regulation are the means by which a design makes volition and productive complexity likely, and appraisal as an epistemic act is the mechanism of productive complexity. Every component is therefore accounted for (Table 1).

Table S1 (supplementary material) records, for each of the nineteen components, its main sources, the counterexamples and limits considered, and the outcome of the test.

Table 1. From nineteen components to one constituting condition and three essential properties.

Outcome	Element of the definition	Components (Sections 6.1–6.3)
Constituting condition: the act by which a situation becomes a challenge	**Volition**: taking the situation on as one's own and committing to a response	Volition; action orientation (its orientation toward action)
Essential properties: necessary, and held in degrees	**Real-world significance:** something beyond the exercise depends on the response	Authenticity
	Productive complexity: outcome not predetermined; demands calibrated to perceived resources	Indeterminacy; relationality; calibrated difficulty
	Growth orientation: learners' development is part of the purpose	Growth orientation
Supporting features: characteristic, often desirable, not essential		Boundedness; productive disequilibrium; integration across boundaries; reflection as integral; feedback systems; stakeholder integration; collaborative structure; scalability
Mechanism: how productive complexity works		Appraisal as an epistemic act
Design means: how a design makes volition and productive complexity likely		Framed rather than found; choice architecture; difficulty regulation

Note: Components from Sections 6.1 to 6.3 were integrated and filtered by the necessity test (Section 6.5). Table S1 gives the sources, the counterexamples considered, and the reason for each outcome.

7. Toward a Definition

7.1 The proposed definition

Based on the analysis presented and the development of essential properties and supporting features, we propose a definition of challenge for the context of Challenge Based Learning as follows:

> **A challenge is a situation of real-world significance to a person or group who voluntarily takes it on as their own and commits to a response. Its outcome is not predetermined, its demands exceed their present capability while remaining within reach of their perceived resources, and its purpose is their learning and development as much as the difference their response makes.**

The definition is stipulative and pedagogical in scope (Sections 1, 3.1, and 4.3). Its clauses state the constituting condition, volition, and the three essential properties set out in Section 6.5. These are real-world significance; productive complexity, whose two aspects, indeterminacy and calibration, each have a clause; and growth orientation. Section 7.2 explains why the condition and the properties behave differently. The paragraphs below explain each clause in turn.

A situation. A situation is the experienced whole in which people meet something that matters and consider how to respond. It includes the participants, with their purposes and histories, the people and conditions they meet, and the relationships through which these become significant. The term comes from Dewey, for whom an individual "passes from one situation to another" and "the immediate and direct

concern of an educator is then with the situations in which interactions take place" (Dewey, 1938a, pp. 42, 43). In Logic, he describes a situation as a contextual whole within which objects and events are experienced and whose pervasive quality holds them together (Dewey, 1938b). A situation can also be indeterminate, unsettled in a way that calls for inquiry, and the people within it are part of what is unsettled (Dewey, 1938b). In our terms, such a situation may call for a response without anyone answering it, and it becomes a challenge when someone takes it on as their own.

An example shows how a situation differs from a topic. Belonging is the kind of Big Idea a CBL challenge might begin with. As a topic, it is general and shared. It can be studied, discussed, and defined, it belongs to no particular people, place, or time, and in itself it calls for no response from anyone in particular. As a starting point, it can lead to a situation, which involves particular learners, their experiences of inclusion and exclusion among peers, the practices of their school, and the possibilities they see for changing what happens there. Because the learners are part of that situation, their understanding and actions help shape how it develops. The word also provides what a response needs, since a response always answers a situation.[3]

Of real-world significance to a person or group. This clause states the first essential property, which Section 6.1 called authenticity. It also gives a precise meaning to "real-world," a term the CBL literature uses constantly and rarely defines. A situation has real-world significance when something beyond completing or assessing the exercise depends on what learners do. Significance in this sense concerns what is at stake. It is distinct from how meaningful learners find the work, which bears on whether they take the situation on as their own (Section 7.2). The stakes can be personal, family, community, or global. Because the stakes are always someone's, and those who take the situation on must recognize them as real, significance varies with the participants and the circumstances of their work. For young learners it may lie in belonging, which shapes their days at school. For adult learners it may lie in community action, where their professional expertise meets their responsibilities as citizens. Neither is more authentic. A definition that ranked global stakes above personal ones would confuse the reach of the stakes with their reality.

No external partner is required. A brief from an organization can carry real-world significance, and so can a situation in a learner's own life, provided the consequences extend beyond meeting an instructional requirement. Those consequences need not be large or public. They may concern a relationship, a practice, or a decision that matters to the people involved. Personal investment helps, but investment alone does not create a consequence. A teacher may frame the occasion, choose the theme, or shape the brief, and the challenge stays authentic as long as something beyond the exercise depends on what learners do.

Who voluntarily takes it on as their own. This clause is the turning point of the definition, since taking on is the constituting act.[4] The phrase was chosen with care. "Accepts" would assume that someone else had made an offer, and "is given" would assume that the situation had been handed to them. "Takes on" is neutral about the occasion, meaning whatever presents a situation to learners as something they might take on: a partner's brief, a teacher's framing, a course requirement, an event in their lives, or something they notice themselves. It also covers the reflexive case that ordinary English expresses in "I challenged myself to."

The preface to the CBL User Guide described the range of origins plainly: "Some we choose, some choose us; some we look forward to, some we dread; some we address, some we try to ignore" (Nichols et al., 2016, p. ii). A situation that chooses us provides an occasion. It becomes a challenge once we take it on, and one we try to ignore remains only an occasion. Taking on does not require choosing the circumstances, since learners may face conditions they would never have chosen and still commit to addressing them. It requires that the commitment belong to them.

This clause matters especially in formal learning, where the work is often required. A course requirement can provide the occasion, but only the learner can do the taking on. The words "voluntarily" and "as their own" do different work here. The first excludes engagement secured only by compulsion. The second requires endorsement, the condition under which an activity first proposed by someone else becomes one a

learner pursues as their own (Ryan & Deci, 2000b, 2017). Together they amount to volition. Section 7.2 sets out the kinds of choice through which volition can be exercised, and Section 7.4 argues that refining an initiating challenge statement is one of them.

And commits to a response. Taking a challenge on involves a commitment, which is firmer than an interest, and the commitment is to a response. The commitment answers the call described above: a situation may call for a response, and taking it on is what commits learners to giving one. A response is the whole course of purposeful action through which learners address the situation, from the moment they take it on. It includes inquiry, decisions about what to do, carrying out those decisions, and the evaluation and revision that follow. Investigation ends in response concepts, the possible courses of action learners develop from what they have found, and learners carry them into Act, where they choose and develop the course they will follow. Carrying out that course reveals consequences that may call for further inquiry, adjustment, or a change of direction, so the response stays answerable to what learners discover and what their actions bring about. The framework's milestones mark points within this course of action, and none of them is the response itself (Section 8.4).

Responses take many forms. Learners may:solve a manageable problem that investigation brings to light; create something new; sustain something that deserves care; recognize people or practices that have gone unnoticed; change what people routinely do; inform and advocate to those with the standing to act; or make continuing commitments that others carry forward.

Most responses combine several of these forms. Response concepts propose them, and the response develops, carries out, and revises them. Whatever its form, a response is judged by its relation to the situation and by the consequences it produces.

Response takes the place that solution held in the framework's earlier vocabulary. Solution named the output of the Act phase, and response names the whole course of action, of which such an output is one part. Response concepts correspond to the framework's solution concepts, although they close Investigate where the published framework develops solution concepts at the start of Act (Section 8.4). Response comes from the same preface quoted above, which used it for how people meet challenges (Nichols et al., 2016, p. ii). The older vocabulary did not prevent developmental practice, and the current CBL framework keeps solution language alongside ownership, inquiry, implementation, and evaluation (Challenge Institute, 2018b).

Inquiry within a challenge serves a decision about how to act. Work that ends in understanding alone, with no such decision, is inquiry in its own right. Understanding may lead learners to change an initial intention, narrow an intervention, or conclude that responsible action requires restraint. Philosophers of action distinguish intentional refraining, in which a person chooses not to do something they could do, from simple omission (Clarke, 2014; von Wright, 1963). Restraint within a challenge meets that standard when learners can identify the actions open to them, explain why they judge those actions inappropriate, and make clear what their decision means. Communicating that reasoning to partners or to those affected often becomes part of the response. Together, these conditions make restraint accountable.

Its outcome is not predetermined. This clause states the first aspect of productive complexity, indeterminacy. It connects to the sense of situation set out above. For those who take it on, the situation is indeterminate, and inquiry is how they make it determinate enough to act (Dewey, 1938b). The clause adds that this inquiry must be able to change what happens. A situation can be unsettled for learners while whoever frames it has already fixed the outcome, and in that case the condition is not met. An adequate response and its consequences have to be worked out through inquiry and action. Along the way, learners make judgments whose adequacy depends on what they encounter and what their actions produce. Whoever frames the challenge may still expect a promising response, since teachers and partners bring experience and reasonable expectations. The condition holds as long as important judgments remain open to investigation and revision. An expected approach may prove unsuitable, or carrying it out may reveal

demands that call for a different course. Several valid approaches often exist, although inquiry may show that only one can be defended.

Its demands exceed their present capability while remaining within reach of their perceived resources. This clause states the second aspect of productive complexity, calibration, and it sets a lower and an upper limit. The lower limit is a requirement of the developmental definition (Section 6.5). Responding must require learners to extend what they can do while leaving them a credible sense that they can do the work. Present capability is what learners can already accomplish. Perceived resources include that capability along with support, time, tools, collaboration, and opportunities to learn. This is how a challenge can ask more than learners can currently do and still be within reach. In a group, the judgment includes how members can combine their contributions and what they still need to develop together.

The biopsychosocial model associates challenge with an appraisal that resources meet or exceed demands, and threat with an appraisal that demands exceed resources (Blascovich & Mendes, 2000; Seery, 2011). Because the limit rests on appraisal and changes as the work proceeds, objective difficulty alone cannot settle it. The properties apply to the challenge as a course of work, judged at the start and throughout, and they need not hold at every moment. Learning that closes an earlier gap is the purpose being fulfilled, and because a response changes the situation, new demands usually follow. Where learners outgrow every demand before the response is complete, the challenge needs recalibration (Section 8.2). Temporary mismatches of this kind are normal within a challenge. If no recalibration follows and the mismatch persists, the experience loses productive complexity and no longer meets the definition.

Its purpose is their learning and development as much as the difference their response makes. This clause states the third essential property, growth orientation. Demands beyond present capability create opportunities for learning but do not guarantee them. Learners might get help, divide the work, or rely on resources that allow them to respond without building the capabilities the setting intends. Naming learning makes its place in the work explicit. It also makes the scope of the definition explicit. The definition is stipulated for learning and education (Sections 1 and 3.1), and growth orientation is what makes it a definition of challenge for that context. In other domains, a challenge may be pursued only for its result (Section 6.4). Development extends learning to what learners become: more capable of judgment, more attentive to consequences, and better prepared to take on difficulty and act with others.

The phrase “as much as” gives both purposes standing without requiring equal weight at every stage. At the start, teachers and partners often hold the learning purpose more explicitly than learners do, and framing can invite learners to share it. A challenge that learners set themselves has no outside framer. What the definition requires is that learning and development be part of what the work is for.

Because the clause states a purpose, a challenge that falls short of its aims can still be a challenge. An unsuccessful intervention may produce substantial learning, and a successful one may reveal further needs. A solution addresses its problem. A challenge can include problems resolved along the way while the wider situation stays open to further response, a contrast that Section 7.3 develops.

7.2 The constituting condition and three essential properties

The clauses of the definition do two kinds of work. One clause states what makes a situation a challenge for particular people. The others state what characterizes a challenge once it exists. Because the condition constitutes a challenge and the properties characterize it, the two behave differently (Section 6.5). This difference explains why the same design can be a challenge for some members of a group and not a challenge at all for others.

The constituting condition. The condition is volition, the learner’s taking a situation on as their own and committing to respond to it. We use volition in the sense given to it by self-determination theory: acting with willingness and personal endorsement, as opposed to experiencing one’s behavior as pressured or controlled (Ryan & Deci, 2000a; 2017, p. 10). Volition in this sense does not mean independence, since

people can volitionally rely on, follow, or be guided by others (Ryan & Deci, 2017, p. 56). In practical terms, it is a sense of ownership of the work. In this account, without volition what remains is an occasion or, where the work is required, an assignment, however complex or well designed.

We therefore propose a constituting threshold: the learner takes the situation on as their own. Self-determination theory treats autonomy as a matter of degree (Ryan & Deci, 2017, p. 56), and the threshold is a distinction we propose within our account. Once learners take the situation on, their endorsement can vary in degree. It can grow or fade as they identify with and integrate the value of the work (Ryan & Deci, 2017, p. 56; 2020). Through this taking on, the three properties become properties of the learner's experience.

Design can support volition but cannot guarantee it. Having options is not the same as volition, and learners may willingly endorse work chosen for them when they agree with or trust the choice (Ryan & Deci, 2017, p. 166). One way design can support volition is through the choices it offers. These are of at least four kinds:

- how far to take part (whether to join, in what role, and to what extent, as in adventure education's challenge by choice; Priest & Gass, 2018; Rohnke, 1989);
- how to investigate (questions, methods, sources, and organization);
- how to respond (the form the response takes and what it should achieve); and
- what the challenge will be (identifying the situation and creating the challenge statement, from a Big Idea or by refining an initiating statement).

The first three kinds are common in other learner-centered approaches. CBL gives the fourth particular weight, since learners help create the challenge itself, and describing challenges only as invitations does not fully capture this role (Section 7.4). Design can also support volition by giving meaningful reasons for the work, acknowledging learners' perspectives, and using non-controlling language (Ryan & Deci, 2017, p. 380; 2020). Full choice of every kind is rare in formal education and is not required. What is required is that learners endorse the work as their own.

Participation can be required, but commitment cannot. The condition is therefore endorsement within constraints. In self-determination theory, autonomy "is not defined by the presence or absence of external influences but rather, when external influences prompt behaviors, by one's subjective assent to those influences" (Ryan & Deci, 2017, p. 59). A compulsory, assessed course can contain a challenge when learners endorse the work and their approach to it. Freedom to decline participation altogether is not required. When learners identify with the value of an activity that others proposed, they experience "a relatively high degree of volition or willingness to act." When they also find it consistent with their other values, their motivation is more autonomous still (Ryan & Deci, 2020, p. 3). Such motivation does not depend on enjoyment, since people can act volitionally on work they judge worthwhile even when they do not enjoy it.

What the condition excludes is a setting that leaves learners nothing to choose or endorse, or that treats compliance as commitment. Choice is the design side of the condition and does not guarantee it. Offering learners a choice of project need not produce ownership (Hendrickx et al., 2023). Digital culture also shows that nominal choice under strong social pressure can fail to secure volition (Section 5.5). This warning applies to classrooms where declining is technically allowed but socially costly. Endorsement therefore has to be shown by evidence and cannot be assumed from the options a design provides.

When the party is a group, the condition applies at two levels. A team takes a challenge on when its members commit to a shared response, but each member's relation to that challenge can still differ. A team can have a challenge while one member, taking part mainly for the grade, has an assignment. Collective commitment can exist alongside uneven individual endorsement, which may grow or fade as the work proceeds. A team's refined statement is evidence of the group's commitment but says little about any one member's. Claims about individual ownership therefore need individual evidence, such as learners' own accounts and the decisions they make (Section 8.3).

The three essential properties. Each property is necessary in the sense of Section 6.5. Where one is absent, the situation is not a challenge, whatever else it offers. Above that minimum, each can be present to a greater or lesser degree in the experience itself.

Real-world significance. The most neglected element of this property is recognition. A challenge may address a globally significant issue and still lack significance for the learners in the room if they cannot see what depends on their response. When it also connects to nothing in their experience, it is unlikely to be taken on at all. This may be one reason why grand-challenge framings, brought into classrooms, can produce compliance where engagement was intended. Significance also grows as learners engage, and how far it grows varies across a group.

Productive complexity. Indeterminacy varies with the number of interacting variables and perspectives, and with how far the response emerges from the work. A situation with few variables and one approved perspective can still be uncertain, but the uncertainty is shallow, since learners resolve it by finding the expected answer. Calibration varies with the fit between demands and perceived resources, and it is the aspect that design techniques can most easily address. Support is part of the complexity. Good scaffolding helps learners work through the complexity without removing it, which is what separates scaffolding a challenge from simplifying it. A situation can be open but poorly calibrated, or well calibrated but closed, and design has to attend to both.

Growth orientation. This property varies with how explicitly learners' development is part of what the work is for. A situation involving harm, deprivation, or failure can support it when addressing the situation also serves that development. The property can also weaken as the work proceeds. Pressure for a successful or innovative result, from partners, showcases, or assessment, can make the outcome the only purpose and leave development as an afterthought. It can also let a team's result come at the expense of some members' growth, as when the most capable members do the decisive work. The property can then differ between a team and its members, and a strong response is no evidence that learners developed through it (Section 8.2). In organizational research, demands that carry potential gains for the person are associated with stronger motivation and performance than demands that only obstruct (Cavanaugh et al., 2000; LePine et al., 2005). Programs built around challenge show developmental gains, although the role of challenge itself in those gains has been theorized more than tested (Hattie et al., 1997; Neill, 2008). Meeting a challenge can also change identity, since having met it changes how people see themselves (Turner, 1969).

Challengeness. Together, the three properties determine a challenge's challengeness: the degree to which a situation, once taken on, shows these properties for the people who took it on.[5] It describes variation above the minimum conditions, and so applies only once a situation has been taken on and each property is present. Challengeness is different from difficulty. Demands that briefly exceed perceived resources can lower it while the challenge continues. Demands that stay beyond reach remove productive complexity, and the experience no longer meets the definition. Like the properties, it is relational and can change as the work proceeds. Whether the kinds of choice offered, or the strength of learners' endorsement, should also count toward challengeness is left to the companion study described in Section 8.3.

Condition, properties, and motivation. Taken together, the condition and the properties support the three needs identified by self-determination theory: autonomy, competence, and relatedness (Nichols, 2025; Ryan & Deci, 2000b). Taking a challenge on as one's own expresses autonomy, and design that supports autonomy makes that taking on more likely. Productive complexity and growth orientation support competence. Real-world significance creates occasions for relatedness through collaboration and engagement with the people affected.

7.3 Distinguishing challenge from related concepts

Challenge and problem. The two words can name the same situation. A problem identifies a difficulty or question to be addressed. A challenge, as defined here, is a situation constituted by a relation: learners take it on as their own, commit to a response, and pursue development by addressing it. Food access in a

neighborhood can involve problems that need solutions and can also become a challenge for learners. Recognizing deprivation as a problem does not stop learners from taking it on as their own or growing through it. The distinction lies in what each concept specifies, and it holds whether a situation is described in negative or positive terms.

Openness alone does not separate the two. Problem-based learning deliberately uses ill-structured problems, which allow many acceptable solutions and many paths to them (Jonassen, 2000; Savery, 2006). A clearer distinction concerns where each term directs attention, and we state it as a proportion: problem is to solution as challenge is to response. Each term in a pair determines the other. A solution is always a solution to something, and whatever it answers becomes a problem, so calling an output a solution defines its starting point after the fact. A response has a different counterpart and a different criterion. It answers a situation, and it is judged by its effect on a situation that continues to develop. A solution is judged by whether it removes the difficulty it addresses, although in practice solutions are often partial, provisional, and revised.

Response is also the broader term. The noun solution usually points to an outcome and leaves the work of reaching it in the background. Response names both what learners identify and create and the course of action through which they get there, including the decisions they make, the reasons they give, and the points at which they change direction. A response may include solutions, and it keeps the situation in view after any particular solution has done its work. Food access, for example, is rarely settled once and for all. Each response changes the situation, and a further response may follow. Judging a response therefore includes the course of action as well as its result (Section 8.2).

This does not make a response less substantial than a solution. A response can include the same deliverables a solution might, such as a product, a prototype, or a campaign. These are parts of the response, which is the whole course of action that produces and carries them out (Section 7.1). What changes is the focus of judgment. A solution is usually checked against the difficulty it addressed. A response is judged against a situation that keeps developing, so its adequacy may need to be judged again as the situation changes.

The pairing of challenge and response has a long history. Toynbee's A Study of History (1934) made challenge and response the pattern behind the growth of civilizations (Section 4.1). He held that the most productive challenge lies between too much and too little severity, an early form of the calibration that the present definition requires. Martin and Membrillo-Hernández (2026) note the cost of his formulation: the challenge comes from abstract historical forces, and the party doing the challenging becomes hard to identify. The proportion proposed here keeps the pairing but not that feature of it. In the present account, a response answers a situation that someone framed, and Section 8.5 considers who that is.

The word itself supports this point. Respond comes from re- and spondere, "to pledge in return," the same root that gives sponsor and spouse. A response is therefore an answering pledge, which links it to the account of the constituting act as a commitment (Section 7.4). Taking on a challenge and responding to it are the same kind of act made at two moments, one made to the situation and one made back to it. Definitions that describe CBL as solving real-world problems can leave the second moment implicit, and the framework's own earlier vocabulary of solution concepts and solutions could likewise leave it implicit.

Challenge and task. A task is an assigned activity with a set procedure and a known standard of completion, and the learner's job is to carry it out. A challenge leaves the path open and gives learners the work of defining it. Tasks still have a place inside a challenge, since investigation involves many of them, but no sequence of tasks adds up to a challenge on its own.

Challenge and project. A project is an extended piece of work organized around a deliverable. In project-based learning, a driving question anchors the project and gives its activities coherence (Blumenfeld et al., 1991; Krajcik & Blumenfeld, 2005). CBL orders its questioning differently. In Engage, an exploratory cycle of

Essential Questions leads to a challenge statement, which then directs the work. A driving question organizes inquiry, while a challenge statement commits learners to action.

Projects vary widely in how much they leave open, so their relationship to challenge depends on the project. A project becomes a challenge when it meets the constituting condition and has the three properties, and many strong projects do. A project with a set deliverable, a set method, and a set standard is a long task. What mainly separates the two is how uncertain the way forward is and who has the agency to define it.

Challenge and threat. The biopsychosocial model distinguishes these two states by how people weigh demands against their resources (Blascovich & Mendes, 2000; Jones et al., 2009; Seery, 2011). Threat arises when demands are judged to exceed resources, and challenge arises when resources are judged sufficient. Because resources include support and the expectation of learning, a challenge can ask more than learners can currently do and still be appraised as a challenge (Section 7.1). The two states have distinct physiological patterns, although both involve engagement with the task (Seery, 2011). They are also not mutually exclusive. A learner can appraise the same situation as both, and the balance between them can shift during the work (Meijen et al., 2020; Uphill et al., 2019). Educational challenges should be designed so that the challenge appraisal dominates. Because perception sets the boundary, the same design will fall on different sides of it for different learners.

Challenge and competition. Both involve working toward goals. A competition measures performance against others, while a challenge is measured against the situation and against what learners could do at the start. Competition does not in itself require learning, since a contest is decided by relative performance and may be won with capabilities people already have. In a challenge, as defined here, learning is an intended purpose, and calibration requires demands that stretch present capability.

Achievement goal research helps explain why this distinction matters. Structures that emphasize outperforming others can encourage performance goals (Ames, 1992). These goals can lead learners to avoid difficulty, particularly when they doubt their ability, while learning goals support seeking out challenging tasks and persisting through difficulty (Dweck & Leggett, 1988). Challenges may still include competitive elements, since how learners interpret comparison matters as much as whether it is present (Ames, 1992). Competition alone does not make a challenge, and a ranking says nothing about whether the situation mattered beyond the contest or whether anyone developed. The reality television example in Section 5.5 shows the relationship clearly. A competition format sets contestants a task and ranks the results. Whether the task becomes a challenge in the present sense depends on how contestants take it on, and the ranking belongs to the format around it.

Challenge and opportunity. These two concepts are closely related, and the relationship needs care because the language of opportunity is often used for what this paper calls growth orientation (Section 7.2). Both look forward and consider what a situation could become. An opportunity is a situation that offers a possible gain to those who can take it up. It may be significant, and taking it may require effort, but nothing in the concept requires that its demands exceed present capability or that anyone commit to a response. An offer of work that matches one's existing skills is an opportunity and involves no challenge.

The two also differ in direction. An opportunity is defined by what it offers the person who takes it, while a challenge points outward, toward a situation that calls for a response and is changed by it (Section 7.1). The two often meet. Working on a challenge can reveal opportunities, and an opportunity becomes a challenge when taking it up demands growth and commits learners to a response. Framing a situation as an opportunity can therefore encourage growth orientation without ensuring it. The property requires that learners' development be part of what the work is for, and the other conditions still have to be met. Section 8.2 makes this its first design principle.

7.4 The statement, the relation, and the unit

The definition in Section 7.1 defines the second of the four senses identified in Section 2.3, which this paper defines as a relation. This section explains how the first and third senses, the statement and the unit, depend on it. Because a situation in the sense of Section 7.1 already includes the people who take it on, defining challenge as a situation and placing it in a relation describe the same thing from two sides.

The learner makes the challenge. A challenge statement does more than describe a situation, and what else it does depends on who creates it. A statement presented to learners by someone else can be read as an invitation, which they may accept or decline. This reading captures the choice the definition requires. However, it fails for the case CBL most hopes for. When learners frame a challenge themselves, no one invites them, and an account that builds an inviter into the concept would make the self-created challenge an imperfect example of the very thing it best represents.

What constitutes a challenge is therefore the learner's own act: taking this situation on as their own and committing to respond to it. This act needs only one party, which is why "I challenged myself to" needs no explanation. A statement that learners create for themselves expresses that commitment directly. A statement presented by someone else stands outside the commitment, as one occasion among others. In a group, a statement proposed by one member is an occasion for the others, and the challenge is constituted when the group takes it on. Whether a partner proposed the situation, a teacher framed it, or learners identified it on their own, the challenge comes into being through the same act.

Engage allows three routes to a challenge statement, which differ in where the framing act takes place:

- Learners may identify the Big Idea themselves and work it through the exploratory cycle of Essential Questions to a statement of their own.
- They may receive the Big Idea from a curriculum, partner, or teacher and place it in context through the same questioning, with the teacher as a partner who brings curricular purposes and helps judge scope and feasibility.
- They may receive a challenge statement directly.

The first two routes keep the framing act inside the learning process. The third removes it, and refinement brings it back. In the terms of the definition proposed in Section 7.1, the framing act moves from a topic or a general statement to a situation the learners are part of: particular people, a setting, and what is at stake for them. Framing does not create the situation, which may call for a response whether or not anyone frames it. It identifies the situation and states it as the learners' own.

Refinement is the most common route in formal education and needs its own explanation. A teacher, program, or partner creates an initiating challenge statement. It is broad, addressed to a whole class, and deliberately unfinished. A partner's brief plays the same role. Because a brief often fixes the deliverable and the criteria for success, it can leave little for learners to narrow. Refinement can then take a second form, in which learners keep the brief's wording and establish their own reasons for taking the situation on. The criterion set out below applies to both forms: a brief is well formed to the degree that what it leaves open, or what it asks learners to make their own, is worth refining. Learners then create a refined challenge statement that narrows the situation to the stakeholders, setting, and questions they will address and connects it to what they care about, or they state why an unchanged brief is now theirs. The initiating statement or brief proposes, and learners' refinement commits them.

Where refinement is genuine, the challenge is as fully constituted as one that learners framed on their own, because the same act has taken place. Refinement may also be nominal, when learners neither narrow the statement nor arrive at reasons of their own for taking the situation on, whether because the initiating statement left nothing open or because they lacked the authority to change it. In that case, refinement has involved no real choice. Learners may still take the work on through another kind of choice (Section 7.2), but the design cannot count refinement as the act. Without some such act, what follows is an assignment, however authentic its subject. Refinement remains the minimum form of the framing act, and a design that relies on it gives up something that a full Engage phase keeps. Ownership established through refinement

may also deepen, or need renewing, as understanding changes. Most of what learners change during Investigate and Act is the response, which stays open to revision by definition. When what they learn shows that the situation itself differs from the one they committed to, they return to the framing work of Engage and revise the statement. Refinement that keeps a brief's wording can meet the constituting condition. The framing of the situation, however, stays with whoever wrote the brief, since learners have endorsed a definition of what matters without making it. Section 8.5 takes up this point.

Refinement also leaves a record. What an educator creates remains an occasion. What learners create, by refining a statement or by framing a challenge themselves, is evidence that they took the situation on. Where a brief's wording is kept, the record is learners' own account of why they took the situation on. These are the most direct documentary evidence of taking on (Section 8.3).

In ordinary usage, "face" and "meet" describe confronting a challenge that need not have been chosen (Section 4.2). The definition sets that sense aside for CBL, where a challenge is something learners take on.

The condition and properties belong to the relation. A statement cannot take anything on, since only a person can. A statement can leave a situation open and frame it toward development, which is why Section 8.2 can test statements for those qualities. However, a statement cannot have real-world significance, which is always significance to someone. Nor can it be well calibrated, because demands are well calibrated only in relation to a particular learner's judgment of their own resources. This is why no review of a curriculum document can establish that a challenge is present, and why the search for a definition built from the properties of statements cannot capture this sense.

A challenge statement's quality is measured by the relation it makes likely. This gives the design criterion the framework has lacked. A challenge statement is well formed to the degree that, for the particular learners it is meant for, it makes them likely to take the situation on and makes the three properties likely to be present. Well-formedness therefore depends on the audience. A challenge statement that works for one group of learners may be poorly formed for another without any change in its wording.

The criterion takes a different form for each kind of statement. An initiating statement created by someone else is judged by whether it leaves enough open to be refined, and whether what it leaves open is the part that matters. A statement that learners create themselves may already name the situation they will act on, and then it also serves as the refined statement. A statement so specific that refinement can only be cosmetic has prevented the act it was meant to prompt. A statement learners create, whether by refining an initiating statement or by framing one outright, is judged by whether it commits these learners to this situation. In a group, a statement one member creates must also work as an occasion for the others, so the criterion applies within the team as well. Learners create statements for an audience that includes themselves, which may be one reason why learner-created statements so often work better in practice than designed ones.

The unit is named by metonymy. The bounded experience is called a challenge after the statement at its center, which stands in for the challenge the unit is meant to contain. This is harmless in everyday speech but damaging in a definition, since it produces accounts that describe the container while meaning its contents. In design and research, it allows a program to run a "challenge" in which no one has taken anything on, and it allows research to attribute to challenge outcomes that only the unit produced. The nano, mini, standard, and strategic levels presented in the CBL User Guide (Nichols et al., 2016) classify units, and they classify challenges only indirectly. Nothing in this classification shows whether the relation exists at any given scale. A strategic unit can contain a compulsory assignment, and a nano unit can contain a genuine challenge.

The unit and the challenge also differ in time and in number. In formal education, a challenge unit almost always has a fixed time frame, set by a term, a course, or a program calendar. A challenge, in the sense defined in Section 7.1, lasts as long as learners stay committed to responding to the situation. It may end with the unit, continue after it, or pass to others through the continuing commitments described in Section

7.1. The fixed time frame is one reason refinement matters, since learners must scope a response that fits the unit. The two also need not match one to one. When three teams each refine the same initiating statement into their own refined statement, one unit contains three challenges, one for each situation a team has taken on.

These relationships can be summarized briefly. The unit contains the statement. A statement created by someone else offers an occasion, and a statement learners create expresses their commitment. Taking the situation on constitutes the relation, and the relation is what the definition defines and what the three properties characterize. The statement is an optional link in the chain. Learners can take a situation on without any statement at all, and in the strongest CBL practice they frame the situation themselves. Reading the chain in the opposite direction, by inferring the relation from the unit or the definition from the statement, is the inference this vocabulary is meant to prevent.

7.5 Challenge as noun and as verb

The fourth sense is different from the other three. Statement, relation, and unit are parts of a single episode, while challenging, the verb, names an orientation that no single episode contains. The orientation appears at two levels: in institutions, which can hold challenging as a stance, and in learners, who can hold it as a disposition. The framework's practitioner guidance points to the institutional level by applying the noun–verb distinction to CBL itself (Challenge Institute, 2018). We adopt its terms, noun adoption and verb adoption, for the two ways an institution can take up the framework, and we keep challenge and challenging for the word.

Under noun adoption, challenge is an event of limited length, used at a set point for a set purpose, as one tool among others. Under verb adoption, challenge is a way of thinking that organizes curriculum and planning and whose language runs through the institution. The grammatical framing in the guidance is more than a loose analogy, because the word itself behaves this way. The corpus evidence in Section 4 shows that verbal uses of challenge are concentrated in epistemic and political registers that the noun reaches less often. To say that an institution challenges assumptions and received answers is to describe a stance it holds. To say that it runs challenges is to describe a schedule.

We suggest that this distinction is diagnostic and bears directly on the definitional problem. Under noun adoption, the statement is the visible product and the unit is the scheduled event. The relation is neither, so it receives attention only through the instincts of individual facilitators. Under verb adoption, challenging is continuous. The learner's relation to the situation receives sustained attention because there is no unit boundary behind which it can disappear. The implementation difficulties described in Section 2.2 are consistent with noun adoption, where a unit is introduced before the institution has developed a stance. In those cases, students spent more time negotiating what the challenge was than working on it and struggled with an open-endedness they had not been prepared for (Kools & van Ravenswaaij, 2023; Martin & Bombaerts, 2025). Whether depth of adoption explains such difficulties is a question for research (Section 8.3).

The distinction also predicts how far learners get to decide what they take on. The relevant measure is a spectrum. It runs from statements handed down complete, through initiating statements that learners refine, to situations learners frame themselves. A simple division between challenges handed to learners and self-identified ones would miss most of what varies. Noun adoption tends toward the first, because a complete statement is what fits a schedule. Verb adoption supports the second and third, because challenging is a stance the institution's members hold. Where a program sits on this spectrum is a possible indicator of how deeply it has adopted CBL. Since choice of the challenge itself (Section 7.2) is what is at issue, it also shows how much room the institution leaves for learners to frame their own challenges.

The verb also has a sense at the level of the learner. For a learner, to be challenging is to be ready to be challenged and to challenge what one finds, including how a situation has been framed. The taking on described in the definition is the moment this disposition is applied to a particular situation. The growth

clause names part of what a challenge develops, since learners come away more ready to take on difficulty. The relation and the orientation reinforce each other. Each challenge taken on can strengthen the disposition, and the disposition makes the next taking on more likely. Noun adoption tends to neglect this cycle, because its attention ends with the unit.

7.6 A proposed vocabulary

We propose a shared vocabulary for challenge in CBL. The proposal revises the framework's own usage. The CBL User Guide uses challenge for the statement learners create in Engage, for the unit that scales from nano to strategic, and for the experience of working through it, without marking the difference, as the passage quoted in Section 2.3 shows (Nichols et al., 2016, p. 15). That economy suited a practitioner guide, but it is also one place where the conflation identified in Section 2.3 takes hold. In the proposed vocabulary, the statement is the challenge statement, the unit is the challenge unit, and challenge is reserved for what learners take on.

Four of the terms below name the four senses identified in Section 2.3: the challenge statement (initiating or refined), the challenge, the challenge unit, and challenging. The others are related terms the analysis has made precise. Each follows from the section given beside it.

One term rests on practice more than on the cross-domain analysis. Response concepts come from practice in the Apple Developer Academies, where learners close Investigate with the courses of action they propose to carry into Act. We include the term because it makes the difference between proposing and carrying out a response usable in design. Placing it at the end of Investigate adapts the published framework, which develops solution concepts at the start of Act (Section 8.4). Like the definition, the vocabulary is judged by what it allows educators and researchers to do (Section 3.1).

Table 2. Proposed Vocabulary

Term	What it names	Section
Situation	The experienced whole, particular to its people, place, and time, in which people meet something that matters and consider how to respond	7.1
Occasion	Whatever presents a situation to learners as something they might take on: a brief, a teacher's framing, a course requirement, an event, or their own noticing	7.1
Challenge	A situation of real-world significance that a person or group voluntarily takes on as their own and commits to a response	2.3, 7.1
Challenge unit	The bounded block of time and structure within which learners are meant to take on challenges, with design qualities that include its length	2.3, 7.4
Initiating Challenge Statement	A broad first statement that opens inquiry. A teacher, program, or partner may create it as a deliberately unfinished occasion for learners, sometimes as a longer brief, or learners may create it themselves	2.3, 7.4

Refined Challenge Statement	The statement through which learners take the situation on, by narrowing an initiating statement or a Big Idea or, with a detailed brief, by establishing their own reasons for taking it on. A statement learners create themselves may need no further refinement, and learners may revise it if investigation shows the situation differs from the one they committed to	2.3, 7.4
Challenging	A readiness, held by learners as a disposition and by institutions as a stance, to be challenged and to challenge what they encounter, including how a situation has been framed.	2.3, 7.5
Response	The whole course of purposeful action and decision through which learners address the challenge they have taken on, as framed in their challenge statement, including its revisions, pivots, and evaluation.	7.1, 7.3
Response Concepts	The possible courses of action that learners develop from the synthesis of their investigation. They close Investigate, and learners carry them into Act, where they choose and develop the course they will follow. They mark a point within the response	7.6, 8.4
Challengeness	The degree to which a situation, once taken on, exhibits real-world significance, productive complexity, and growth orientation for those who took it on	6.5, 7.2

In everyday classroom speech, “the challenge” will continue to name the unit, and little is lost by that. Precision matters in design documents, research, and reporting, and three conventions follow for those settings:

- Say challenge unit when the bounded experience is meant, reserve challenge for what learners take on.
- Name challenge statements by kind, initiating or refined, since the two are judged by different criteria (Section 7.4).
- Report outcomes as outcomes of a challenge only when there is evidence that learners took the situation on, such as a refined challenge statement or, where a brief’s wording was kept, learners’ own account of why they took the situation on.

8. Implications

8.1 Theoretical: the object of design relocates

The most important implication concerns where the definition places the object of pedagogical design.

Problem- and project-based learning offer established accounts of the problems, driving questions, and projects around which learning is organized. These approaches also attend to learners’ ownership, purposes, and relationships with the work. The question here is narrower: what must an account of challenge specify that cannot be found by examining the problem, question, statement, or unit alone?

The definition proposed here specifies what such an examination cannot find. Its constituting condition centers on an act that only a learner can perform. Real-world significance is always significance for someone, and calibration is fully relational, since it lies in the fit between demands and the learner’s

judgment of their own resources. A challenge therefore goes beyond anything an educator can write down. What an educator can write down is a situation framed so that particular learners are likely to take it on. Beyond that, an educator can build the conditions under which learners frame such situations for themselves.

Making the relation between learner and situation explicit is the theoretical contribution this paper proposes for CBL. The account gives conceptual form to a commitment already present in the framework's practitioner guidance. It also offers an explanation for three observations often made in practice: CBL implementations are sensitive to the quality of facilitation, identical designs produce different results with different groups, and the work depends on learners' relation to the situation more than on the challenge statement or unit. These observations still need systematic evidence.

This shift also explains why the field's problem-shaped definitions did not fit, since they describe an object where the construct is a relation. Section 7.4 suggests why. Of the four senses of the word, the statement is the one most easily examined on a page. Definitional effort therefore settled there, and a statement of work is exactly the kind of object to which the idea of a problem attaches.

This account identifies the learner's relation to the situation as CBL's organizing commitment. The claim concerns what this definition makes explicit, and it does not claim that the relation is unique to CBL. Strong problem- and project-based practice may also meet the definition, which identifies an educational phenomenon wherever it occurs. For CBL, the contribution is an explicit account of that phenomenon and of how Engage, Investigate, and Act can support it. Finding out whether neighboring pedagogies give the relation a different theoretical status would require a separate comparative analysis.

8.2 Practical implications

If challenges cannot be fully specified, they can still be made likely. The definition implies two kinds of design work: creating a statement whose qualities make the relation likely, and establishing conditions under which learners can take it on. The first concerns the statement, and the second concerns facilitation and the institutional setting, which correspond to the noun and the verb of Section 7.5. Four implications follow, one for the constituting condition and one for each property. Detailed design guidance is left to a separate practitioner paper.

Choice becomes a design commitment. The definition implies that learners need choice they recognize as theirs. A design may offer only some of the four kinds of choice (Section 7.2), and one that offers only choice of method can still support volition, provided it claims no more than it offers. Choice of the challenge itself makes the constituting condition most likely. Where a teacher or partner provides the initiating statement, refinement is where this choice is exercised or, with a detailed brief, where learners' endorsement is established, and it is where the challenge is most often constituted or lost. Martin and Bombaerts's (2025) observation bears on this step: students spent more time negotiating what the Challenge's project problem was than working on it. Some of that negotiation may be confusion produced by a vague statement, and some may be refinement doing its work. Telling the two apart is itself a research question (Section 8.3).

Significance depends on stakes that learners recognize. Real stakeholders, consequences, and audiences can provide real-world significance, and the test in Section 7.1 still applies: something beyond the exercise must depend on the learners' response. A teacher who chooses the theme or shapes the brief does not weaken this property, provided the stakes are real and recognized. Significance can also grow as learners meet people and investigate conditions, so a shared brief may become significant to different learners in different ways.

Calibration is continuous. Because appraisal sets the boundary between challenge and threat, the fit between demands and perceived resources has to be judged throughout the work, as investigation reveals new demands and learners' capabilities grow. Game design's dynamic difficulty adjustment (Hunicke, 2005) and adventure education's arc of challenge (Prouty et al., 2007; Walsh & Golins, 1976) offer models that

classroom practice, CBL included, has rarely drawn on. Learners with different prior experience may also appraise the same demand differently, an equity question that game studies has arguably addressed more directly than education has (Section 5.5).

Framing is a decision about purpose. The same situation, whether a neighborhood's food access, a legacy codebase, or a declining habitat, can be stated as a gap to close or as a situation in which learners will develop as they act. Either statement can begin from a deficit. What the framing decides is whether learners' development is part of the purpose. Because that purpose includes development, evidence of it needs planning alongside the work. The products of a response can show learning and contribution, but producing them does not establish either (Section 8.3).

The definition also yields four tests for the statement learners will act from. This is normally the refined challenge statement, whether learners narrowed an initiating statement or a Big Idea of their own, or made a detailed brief their own without changing its wording:

- Does the statement call for action, with a verb and an actionable idea, as the CBL User Guide recommends (Nichols et al., 2016, p. 51)?
- Does it leave important judgments about method and outcome open, including the form the response will take?
- Does it identify stakes that these learners will recognize as real?
- Does it make the learners' development part of the purpose, alongside the difference the response will make?

Where learners keep a brief's wording, the first two tests apply to the brief itself, and the last two can be met by learners' own account of why they are taking the situation on.

The first test follows from the commitment to a response, the second from indeterminacy, the third from real-world significance, and the fourth from growth orientation. A detailed brief kept unchanged most often fails the second test, since briefs tend to fix the deliverable. Calibration has no test of its own, since it depends on how particular learners appraise their resources and cannot be read from wording (Section 7.4). An initiating statement is tested differently, by the single question of whether what it leaves open, or asks learners to make their own, is worth refining.

A further test concerns the setting, which no wording can settle. Does the setting leave learners something to choose, room to redirect or reframe the statement, and room to say so when they cannot endorse it? This test follows from volition (Sections 7.2 and 7.5). Where the setting fails it, no challenge statement can bring a challenge into being, and even a well-formed statement can fail for reasons that no rewording can fix.

Five failure modes recur. Each corresponds to one element of the definition and can occur in a full or a partial form. In its full form, a failure removes something the definition requires, and the challenge unit produces no challenge in the sense of Section 7.1. In a partial form, it leaves a challenge low in challengeness. All five name likely tendencies that the conceptual analysis cannot establish as necessary outcomes.

- The compulsory challenge leaves learners nothing to choose or endorse and risks compliance. It is likely the most common failure in formal education, where assessment structures often produce it.
- The sanitized challenge removes real stakes to reduce risk and tends to become an exercise.
- The scripted challenge fixes the method and the outcome in advance and tends to become a task.
- The runaway challenge exceeds perceived resources and can push learners into threat, with the avoidance the biopsychosocial literature predicts and the struggles the CBL implementation literature reports (Kools & van Ravenswaaij, 2023). Its opposite, a challenge set within present capability, risks completion without extending what learners can do.
- The disguised problem has real-world significance and productive complexity but does not make development an explicit purpose, and it risks a solution without development.

These failures differ in kind. The compulsory challenge concerns the constituting condition and is the failure the setting test above detects: no challenge is constituted. The other four concern the properties. In full form, each removes a property, so what remains is an exercise, a task, a threat, or a problem pursued only for its solution, or, where demands sit within present capability, work that does not extend what learners can do. In partial form, each weakens a property and the challenge remains. Where full becomes partial is a matter of judgment, and practical thresholds remain provisional (Section 8.3).

8.3 Research directions

The definition is offered as a research tool, and its value should be judged by the research it makes possible.

Operationalization and measurement. The condition and the three properties need operational indicators. Volition, calibration, and significance depend on the learner's own act, appraisal, and situation. They will therefore require measures based on learner reports instead of reviews of design, a methodological shift with implications for how CBL research is done. Volition in particular calls for an instrument that distinguishes taking on from compliance and records how strongly learners endorse the work once they have taken it on. To our knowledge, no current CBL measure attempts this. Other fields offer starting points. These include psychophysiological measures of challenge and threat states (Blascovich & Mendes, 2000; Seery, 2011) and validated self-report scales of perceived challenge in games (Denisova et al., 2020) and of challenge stressors at work (Cavanaugh et al., 2000). CBL research has not yet used any of them.

Refined statements as a corpus. Section 7.4 argues that a refined challenge statement is the most direct documentary evidence that learners took a situation on. A refined statement is evidence to investigate and not proof, since learners can write convincing ownership language to meet an assessment requirement. It becomes stronger evidence when paired with learners' explanations, the important decisions they make, and their later reflections. Even so, refined statements are unusually easy to study.

Paired with the initiating statements they come from, where these exist, refined statements allow questions that CBL research has not been able to address. Researchers could ask how far learners actually narrow what they are given, whether the distance between initiating and refined statements predicts engagement or outcomes, and whether refinement in a given implementation is substantive or cosmetic. The last question is the operational form of the distinction Section 8.2 could only point to. Such collections already exist in the files of every program that asks learners to restate their challenge, and to our knowledge none has been analyzed.

Comparative studies. The central empirical question is whether challenge-framed learning produces outcomes that problem-framed learning does not, when significance and productive complexity are held constant. To our knowledge, this has not been tested, because the constructs could not be distinguished. The failure modes identified in Sections 7.4 and 8.2 now make it possible to specify how such a comparison could be designed.

Challengeness. The three properties are dimensional. This implies that learning experiences have challengeness in degrees once the constituting condition is met and each property is present. Developing parameters and thresholds for challengeness, meaning what makes a challenge more or less of one, is the natural next step and the subject of a future study.

Longitudinal and identity outcomes. Growth orientation implies effects on identity as well as on skill. Adventure education's longitudinal evidence (Hattie et al., 1997) suggests that these effects can be measured, and CBL has not tried to measure them. Challenge seeking, which Hattie et al. (1997) record as an outcome under the label challengeness, is one possible measure. It corresponds to the learner-level sense of the verb described in Section 7.5.

Cross-cultural validity. Because the definition depends on volition, its cross-cultural validity is an empirical question with high stakes (Section 9.1). Studies in educational cultures with more collective ideas of agency

could test whether the condition and the three properties hold there. They could also test whether a group taking a challenge on, which the definition already allows, should be the default formulation in some of these cultures. Given CBL's global adoption, this is among the most important questions the definition raises.

8.4 Relation to the CBL Compass and the three phases

The definition strengthens the existing CBL structure. The changes it proposes are to vocabulary, response where the framework used solution, response concepts where it used solution concepts, and the terms in Section 7.6. The three phases remain as they are. One milestone is placed differently, as a proposed adaptation described below.

The CBL Compass (van den Beemt, van de Watering, & Bots, 2022) describes variation in CBL implementations across dimensions that include the nature of the challenge, stakeholder involvement, and learner autonomy. The definition supplies the construct around which the Compass's dimensions vary. The two tools are complementary. The Compass describes the range of implementations, and the definition specifies what every implementation in that range is meant to bring about. Because the definition identifies a phenomenon, the Compass's dimensions can also be read as describing how likely a given implementation is to bring it about, in CBL and in neighboring approaches alike.

The three phases map onto the condition and the properties, and the framework's milestones mark where each is secured.

Engage is where significance is built, the situation is taken on, and the framing that shapes indeterminacy and invites growth orientation is set. Learners work through the exploratory learning cycle toward a refined challenge statement, whether from a Big Idea or from an initiating statement they were given, and that statement is the phase's milestone. In this account, Engage is normally where the challenge comes into being. Learners may return to its framing work if investigation shows that the situation itself differs from the one they committed to, while most later changes belong to the response.

Investigate is where indeterminacy is worked through and calibration is most active, since during investigation learners find out whether their resources match the demands. In the published framework, Investigate ends with a synthesis, and solution concepts are developed at the start of Act (Challenge Institute, 2018a). We propose an adaptation where Investigate ends with response concepts, which Act then develops, carries out, and evaluates.

Act is where the response is carried out and evaluated, and where significance is tested against consequences. It is also where growth orientation either shows itself in learners' changed sense of what they can do or fails to. Its milestone is the evaluation of the response, which asks how effective it was.

Sections 2.1, 7.1, and 7.3 argue that naming the output a response matters more than a change of vocabulary usually does. The older term carried the idea of a problem back into a phase the framework had tried to keep free of one.

Two refinements follow. First, the Engage phase carries more weight than its position suggests. It is where the constituting condition is normally met and where the framing that shapes two of the three properties is set. A challenge poorly framed in Engage is hard to repair later. On the present analysis, the framework's decision to place learner-created challenge statements in this phase is its most important design decision.

Second, calibration deserves explicit status in the framework. At present, it is implied in facilitation guidance, while the cross-domain evidence suggests that it is a primary design activity that continues across all three phases.

8.5 The framing question

An account that places volition at the center of the constituting condition invites an objection that deserves a direct answer. Martin and Membrillo-Hernández (2026) offer a genealogical and discourse-analytic review of CBL in engineering education. They find that its literature focuses on individual agency while hiding how challenges are constituted. They observe that dominant formulations "start from an object whose importance has already been authorized through an industry brief, policy framework, stakeholder agenda, or civilizational imperative," and that "the initial designation of what matters and why often precedes student participation" (p. 6). On this reading, placing the constituting act in the learner's taking on describes the moment after the decisive one has passed. Refinement would then legitimize an agenda set elsewhere while leaving the authority to frame it untouched.

The finding is well supported, and we accept it as a description of the implementations reviewed. Its scope is worth stating precisely, as the authors themselves do. The corpus is engineering and STEM higher education, drawn from seven literature reviews. The authors note that their claims concern how CBL is represented in synthesizing texts and "do not convey what occurs in CBL classrooms or the intentions of CBL practitioners" (p. 14). What the review documents with unusual clarity is a pattern in which an external party, most often industry, supplies the challenge.

The authors' own data over time show that this pattern developed later. External partnerships appear in about 9 percent of studies in the foundation phase from 2001 to 2014, rise to 40 percent in the consolidation phase, and exceed 77 percent in the expansion phase from 2019. The partner-authored challenge, most often from industry, is therefore a feature of CBL's recent institutional history in engineering education. It is not part of the framework's design, which from the start asked learners to work with experts and community members. The authors observe that this association "was not present from the outset but developed through a contingent historical trajectory" (p. 33), a conclusion that holds for the engineering lineages their corpus covers.

A further and more specific point has been recorded in the framework's own literature, although its consequences have not been drawn out. Two of the formative lineages, STAR and Apple, differ on exactly who determines the challenge. Dikilitaș et al. (2025b, p. 21) state this plainly. Under the Apple model, students would generally determine the nature of their challenge, while educators using the STAR approach determined the challenge for their students. They add that the STAR approach "predetermines the challenges and expect [sic] particular solutions which would not be the case for the Apple's CBL model." Gallagher and Savage (2023, p. 1146) reach the same conclusion from the review literature, observing that "a key demarcation between two of the main approaches (Apple and STAR) is whether students or educators define challenges." They add that such disagreements about pedagogical control suggest that CBL's apparent coherence hides internal tensions rooted in its different origins.

The question of framing authority is therefore a known division within the framework's own traditions. External criticism has brought it to the surface more than it has discovered it. It has received no theoretical treatment because the field lacked an account of what constitutes a challenge in the first place.

This matters for the objection because the framework places the framing act in a phase that the documented pattern removes. The movement from Big Idea through Essential Questions to challenge statement is a structured opportunity to ask what matters here and why. The three routes described in Section 7.4 differ in whether that opportunity is taken. Where a partner supplies a challenge statement directly and leaves nothing to refine, Engage collapses and the framing act moves out of the learning process altogether. The critique therefore applies most strongly to implementations that have removed the phase in which the politicization its authors call for would have a place. Their first principle, explicit politicization, asks students to consider who benefits from framing an issue as suited to engineering intervention and what structural conditions produced it. These are Essential Questions in the framework's own sense, and the phase designed to hold them is the one the industry-partnered variant tends to skip.

Two concessions follow, and both are real. The first is that volition secures ownership without securing political literacy. A learner may frame a challenge entirely on their own and still frame it in terms taken from a discourse that treats a structurally produced condition as a technical problem to optimize. Nothing in the definition prevents that. The remedy lies in the analytical content of Essential Questions, which the constituting condition cannot provide.

The second concession is that a challenge set entirely within the classroom is authorized just as surely as one briefed by industry, through a curriculum, a standard, and an assessment system. Its authority is less visible because there is no external party whose interests can be read from a brief. Teacher partnership in framing moves the authority question but does not settle it. In practice, this means specifying what authority affected people keep: the standing to contest how a situation has been framed, to reject a proposed intervention, and to influence judgments about whether a response was adequate. A design that secures learners' commitment but leaves those affected without such standing has answered the second question and left the first untouched.

Even so, the definition makes a specific contribution to this debate. Martin and Membrillo-Hernández argue that CBL discourse hides how challenges are constituted. Section 7 supplies an account of how challenges are constituted, and the two projects meet there. Their third principle, reflexive self-authorship, invites students to ask which challenges they consider worth engaging with, which commitments they are accepting, and whether a project is one they can recognize as partly their own. A commitment-based account of the constituting act makes these questions possible to ask. This agreement is notable, since one route to it runs through conceptual analysis and the other through critical pedagogy. Asking who authorized a situation and asking what makes it a challenge for these learners are different questions, and a full account of Challenge Based Learning needs both. The answer to the second does not settle the first.

9. Limitations and Conclusion

9.1 Limitations

Four limitations apply to these claims.

First, the etymological and corpus analysis is limited to English, and "challenge" has no exact equivalent in many languages. The semantic structure documented in Section 4 may not transfer, which matters for a framework adopted worldwide.

Second, the source corpus is in English and weighted toward Western scholarship, and the cross-domain mapping is purposive. Within each domain, we sought the most important and representative sources (Section 3.1), so a fuller search could find components this one missed. The CBL corpus was extended with AI-assisted literature mapping, whose coverage reflects the indexes of the tools used. Citation chaining reduces that bias but does not remove it. The volitional condition in particular may reflect culturally specific assumptions about individual agency, and because the definition depends on volition, this limitation carries particular weight. Self-determination theory distinguishes volition from independence. A person can volitionally rely on others' guidance and endorse duty and responsibility to them, and critiques of autonomy as a Western preoccupation apply to individualism more than to volition in this sense (Ryan & Deci, 2017, pp. 56–57, 71). This narrows the concern without removing it, since the argument is conceptual and its cross-cultural testing remains open (Section 8.3).

Third, the study is conceptual and does not test anything empirically. It proposes a definition and predicts what follows from it, and Section 8.3 sets out how those predictions could be tested.

Fourth, conceptual framework analysis is interpretive by design. A different team working with the same corpus might weigh components differently, and the authors' involvement in the framework, noted in the

Declaration, may shape what they see. For these reasons, we have made the necessity test and the list of components explicit, and we have not presented the definition as a finding that emerged on its own.

9.2 Conclusion

Challenge Based Learning has operated for two decades without clearly defining its organizing concept. This paper has argued that the omission has consequences. It leaves the framework underspecified in theory, inconsistent in practice, and unable to build cumulative evidence. The paper has tried to address this gap by looking beyond CBL to the many fields in which challenge has been thought about more carefully.

That survey shows a striking agreement. Psychology, sport science, organizational psychology, game design, and adventure education arrive at the same structural claim, partly through shared roots in appraisal theory and partly by separate routes. In each, challenge is a relation between demand and perceived capacity, and no property of a situation accounts for it. Add the volitional condition that the developmental traditions insist on, the growth orientation that separates challenge from hindrance and from a problem pursued only for its solution, and the real-world significance that CBL requires, and the definition follows from choices this paper has made explicit. A simple list of these elements hides the particular standing of volition. Volition is the one element that only the learner can supply, and it sits beneath the list.

We have proposed a definition for a challenge in terms of Challenge Based Learning as a situation of real-world significance to a person or group who voluntarily takes it on as their own and commits to a response; its outcome is not predetermined, its demands exceed their present capability while remaining within reach of their perceived resources, and its purpose is their learning and development as much as the difference their response makes. Volition is its constituting condition, since the voluntary taking on is what makes a situation a challenge for someone, whatever the origin of the occasion. Real-world significance, productive complexity, and growth orientation are its essential properties. The definition also works as a diagnostic tool. Where learners have not taken the situation on, it remains an occasion or, where the work is required, an assignment. Where a property is missing, what remains is better described as an exercise, a task, a threat, or a problem. Where a property is present but weak, the situation is a challenge low in challengeness (Section 8.2).

Separating the senses of the word proved as important as defining any one of them. The challenge statement offers an occasion. The challenge as relation is what a learner's taking on constitutes. The challenge as unit is the container named after its contents. Challenging is a stance that no container holds. A field that had not distinguished these senses was trying to define four things at once, which is why its definitions kept describing characteristics instead.

The vocabulary proposed in Section 7.6 gives each sense its own term: initiating and refined challenge statements, the challenge, the challenge unit, and challenging. It also names what learners work toward as a response, which answers a situation and stays open to revision as the situation changes (Sections 2.1, 7.1, and 7.3). Used in design documents, research, and reporting, this vocabulary would allow the field to say which sense it means, to name its outputs in terms that keep the challenge open, and to report an outcome as the outcome of a challenge only when learners have taken the situation on.

The most important consequence of the definition concerns what educators design. In CBL, the object of design is the relation between learners and a situation, and the statement and the unit are ways of making that relation likely. This is what the definition makes explicit for CBL, although strong practice in neighboring pedagogies may share it (Section 8.1). Challenges are situations of real-world significance that learners take on as their own, whether offered to them or identified by them. Their outcome is open, their demands are calibrated to what those learners believe they can bring, and their purpose is what the learners become in meeting them as much as the difference their response makes. A framework that states this clearly can defend its theoretical position, guide its practitioners, and tell its researchers what they are studying.

Declaration of Interest

The authors are affiliated with the Challenge Institute, an organization established to develop and extend Challenge Based Learning, and one is a co-author of the framework's foundational white paper (Nichols & Cator, 2008) and user guide (Nichols et al., 2016). The comprehensive literature survey cited at several points in this article (Perna et al., 2023) was published by that organization, a circumstance noted by Martin and Membrillo-Hernández (2026, p. 19). Readers should weigh the account of the framework's history in Section 1 accordingly. Where independent sources were available for historical and empirical claims about CBL, they have been preferred, and the periodization reported in Section 1 is drawn from a review conducted outside the Challenge Institute.

Use of Artificial Intelligence

The authors used artificial intelligence (AI) tools in two ways. In the research, Elicit and a large language model (Claude Opus 5.5, Anthropic) connected to OpenAlex supported the mapping of the CBL literature, followed by citation chaining (Section 3.1; Note 2). The authors screened all retrieved sources and read every cited source themselves. In the writing, the same model was used throughout the drafting process. Some passages were drafted by the model from the authors' arguments, notes, and instructions, and were adopted, in some cases verbatim, after the authors reviewed and approved them. The model also edited existing text for clarity and concision, suggested alternative wording, checked cross-references, terminology, spelling, and formatting, and tested passages for internal consistency. The concepts, analysis, proposed definition, and conclusions are the authors' own, and every AI-drafted passage reflects positions the authors formulated or accepted. The authors take full responsibility for the content of the paper, including the accuracy of its sources and citations. No AI tool is credited as an author.

Notes

[1] The sequence can be traced through the published record. Giorgio and Brophy (2001) set out the six stages of the STAR Legacy Cycle for biomedical engineering education. The Apple white paper (Nichols & Cator, 2008) described Challenge Based Learning through a set of elements, among them the Big Idea, the challenge, and guiding questions, without grouping them into phases. The three phases of Engage, Investigate, and Act first appeared in the CBL User Guide (Nichols et al., 2016), which arranged those existing elements into a sequence (Perna et al., 2023, p. 16). Neither the white paper nor the User Guide draws on the STAR Legacy Cycle. One of the present authors co-authored the white paper, the User Guide, and the 2023 survey; the chronology offered here rests on those published sources, which readers may consult directly.

[2] The model was Claude Opus 5.5 (Anthropic), connected to OpenAlex through the Model Context Protocol.

[3] Dewey's (1938a, 1938b) account informs both the use of situation and the relation between inquiry and action proposed here. For Dewey, inquiry transforms an indeterminate situation into a determinate one, though such a resolution need not settle every issue in the wider course of experience. The requirements of ownership and commitment to a response belong to the pedagogical definition and go beyond Dewey's account. See especially chapters 4 and 6.

[4] Act is used here in its philosophical sense, something a person does. It is distinct from the Act phase of the CBL framework, which this paper capitalizes. The constituting act normally takes place in Engage.

[5] The term has an earlier use. In Hattie et al.'s (1997) meta-analysis of adventure education, challengeness is one of the outcome subdomains grouped under "Adventuresome," glossed only by the examples

"venturesome, challenge seeking, adventurousness" (Table 1), and Neill and Richards (1998) retain it in their summary of that category. There it names a disposition of the person, an inclination to seek out challenges, and it appears only in tables, without a definition. The present paper uses the word for a property of a challenge: the degree to which a situation, once taken on, exhibits the three essential properties for those who took it on. The two senses are related. The disposition corresponds to the learner-level sense of the verb in Section 7.5, and it is among the things a challenge high in challengeness may develop.

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Supplementary Material

Table S1. The nineteen components and the outcome of the necessity test (Section 6.5).

Component	Dim.	Principal sources	Counterexamples & limits	Outcome	Reason
Indeterminacy	O	Barrows & Tamblyn (1980); Ferraro et al. (2015); Juul (2013); CBL corpus (5.1)	Televised technical round with a set recipe; a task with a known method	Essential: productive complexity	Without it the experience is a task with a predetermined outcome
Authenticity	O	Grasso & Burkins (2010); Lucena et al. (2008); Neill (2008); CBL corpus (5.1)	Ropes courses and games with nothing at stake beyond the exercise	Essential: real-world significance (stipulated)	CBL asks learners to address situations whose outcome matters to someone
Relationality	O	Blascovich & Mendes (2000); Jones et al. (2009); Podsakoff et al. (2023); Hunicke (2005); Luckner & Nadler (1997)	Early challenge–hindrance work classifies demands whoever meets them	Merged into productive complexity	It is how calibration works, since the fit is judged by the learner
Growth orientation	O	Cavanaugh et al. (2000); LePine et al. (2005); Walsh & Golins (1976); Brown (2008)	Engineering and design client work aimed at the deliverable alone	Essential (stipulated)	It is the developmental sense the definition serves; the domains supply its content
Boundedness	O	Nichols et al. (2016); Challenge Institute (2018); grand challenges literature (5.5)	A challenge can outlast the unit that houses it (7.4)	Supporting feature	A property of units more than of challenges
Volition	O	Priest & Gass (2018); Rohnke (1989); Suits (1978); McGonigal (2011)	Imposed challenge stressors (Cavanaugh et al., 2000); viral dares taken up under social pressure	Constituting condition (stipulated)	The act by which a situation becomes a challenge for someone
Action orientation	E	Nichols et al. (2016); Kolb (1984); IDEO.org (2015)	Inquiry that ends in understanding alone	Absorbed into the constituting condition	Belongs to the commitment to a response
Appraisal as an epistemic act	E	Blascovich & Mendes (2000); Jones et al. (2009); Tuckey et al. (2015)	None considered	Mechanism of productive complexity	Explains how calibration operates
Productive disequilibrium	E	Dewey (1938); Kolb (1984); Walsh & Golins (1976)	A challenge can stretch learners without unsettling their assumptions	Supporting feature	Describes how learning often proceeds
Calibrated difficulty	E	Csikszentmihalyi (1990); Ericsson et al. (1993); Luckner & Nadler (1997); Priest & Gass (2018)	Moderate evidence for the balance (Fong et al., 2015; Macnamara & Maitra, 2019); challenge and threat can co-occur	Essential: productive complexity (fit evidence-led; lower limit stipulated)	Below the floor, responding need not extend capability; above the ceiling, threat tends to follow
Integration across boundaries	E	Höffken & Lazendic-Galloway (2024); Sung et al. (2024); National Academy of Engineering (2008)	Challenges within a single discipline	Supporting feature	Characteristic without being necessary
Reflection as integral	E	Kolb (1984); Walsh & Golins (1976); Sung et al. (2024)	Reflection turns experience into learning without making a situation a challenge	Supporting feature	Essential to good practice (8.2) more than to the concept

Framed rather than found	M	Ferraro et al. (2015); George et al. (2016); IDEO.org (2015)	Challenges learners frame for themselves have no outside framer	Design means	One way a design makes volition and the properties likely
Scalability	M	Nichols et al. (2016); Perna et al. (2023)	Scale says nothing about whether the relation obtains (7.4)	Supporting feature	The design side of boundedness
Choice architecture	M	Priest & Gass (2018); Rohnke (1989)	Offered choice need not produce ownership (Hendrickx et al., 2023)	Design means	The design side of volition
Difficulty regulation	M	Hunicke (2005); Prouty et al. (2007)	None considered	Design means	The design side of calibration
Feedback systems	M	Przybylski et al. (2010); Sweetser & Wyeth (2005)	A challenge can proceed with little designed feedback	Supporting feature	Supports learning within a challenge
Stakeholder integration	M	Dikilitaş et al. (2025a); George et al. (2016); Höffken & Lazendic-Galloway (2024)	A challenge with no external partner (7.1); partners as the source of the challenge became dominant only in recent engineering CBL (Martin & Membrillo-Hernández, 2026)	Supporting feature	Treating it as required narrows the construct
Collaborative structure	M	Neill (2008); Jenkins (2006); CBL corpus (5.1)	A solo challenge is still a challenge	Supporting feature	Characteristic without being necessary

Note. Dim. gives the dimension: O, ontological; E, epistemological; M, methodological. Section numbers in bracket