

SIMULATION-BASED AND GAME-BASED LEARNING IN FINANCE EDUCATION: DESIGN MECHANISMS, APPLICATIONS, RISKS, AND FUTURE DIRECTIONS

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Abstract: Finance education requires more than recalling concepts or applying isolated formulas. Learners must coordinate information, make sequential decisions under uncertainty, observe delayed consequences, and explain why an apparently successful choice may still be financially unsound. Simulations and serious games address this challenge by turning a financial model into a rule-governed environment in which learners can act, receive feedback, revise strategies, and compare outcomes without incurring real losses. This paper reviews the technical and instructional foundations of simulation-based and game-based learning in finance education. It distinguishes simulations, serious games, and gamification; explains scenario engines, decision loops, feedback systems, debriefing, and process-based assessment; and examines applications in personal finance, investment, enterprise finance, accounting, and monetary policy. The review argues that learning does not result from competition or engagement alone. Reliable outcomes depend on alignment among intended competencies, model validity, action and reward structures, feedback, guided reflection, and transfer assessment. Major risks include misleading simplification, short-horizon incentives, unequal prior gaming experience, inaccessible interfaces, invalid learning analytics, and weak transfer to real financial behavior. An outcome-aligned design framework is proposed to connect model construction, instructional support, assessment, and governance. Future development should emphasize adaptive but transparent scenarios, explainable learning analytics, collaborative multi-role simulations, controlled use of authentic data, and longitudinal evaluation. Simulations and games are most valuable as structured environments for deliberate financial practice, not as substitutes for instruction, reflection, or professional judgment.

Keywords: Finance education; Simulation-based learning; Game-based learning; Serious games; Experiential learning

1 INTRODUCTION

Financial competence involves decisions whose consequences unfold across time. Budgeting links income, consumption, debt, insurance, and saving; investment connects return, volatility, diversification, liquidity, and transaction costs; enterprise finance connects pricing and demand with working capital, cash flow, financing, and financial statements. Classroom exercises can isolate these relationships, but students seldom have safe opportunities to experience their interaction, revise a decision, and observe an alternative outcome.

Simulation-based and game-based learning create such opportunities, but the terms require separation. A simulation represents selected features of a real or hypothetical system and allows users to intervene in that representation. A serious game adds explicit goals, rules, challenge, and responsive outcomes for a primary purpose beyond entertainment. Gamification uses selected game-design elements in a non-game context [1]. A points system attached to a quiz is therefore not equivalent to a market simulation in which prices, portfolios, and constraints change after each decision.

The mechanism is more important than the label. Garriss, Ahlers, and Driskell describe an instructional game as an input–process–output system in which game characteristics influence a recurring cycle of user judgment, behavior, and feedback [2]. Game-based learning also combines cognitive, motivational, affective, and sociocultural processes [3]. A theory of gamified learning accordingly treats game attributes as influences on learning-related behaviors or attitudes rather than direct causes of achievement [4]. Experimental evidence further indicates that different elements, including badges, leaderboards, avatars, narratives, and teams, do not satisfy the same psychological needs [5].

The broader evidence is encouraging but conditional. Meta-analyses report learning advantages for serious games and computer-based simulations under some comparisons, while showing that multiple sessions, active rather than passive game content, collaboration, and integration with other instruction can matter [6-7]. A systematic review and meta-analysis of digital games similarly emphasizes the contribution of design and research conditions rather than the medium alone [8]. Debriefing is especially important because experience must be reconstructed and connected to concepts after play [9]. Transfer is a separate question: performance inside one scenario does not establish that a learner can apply the same principle to a different product, institution, time horizon, or workplace setting [10].

Finance provides a diverse application domain. A multi-country experiment found that an online game-based course improved near-term financial literacy, with effects varying across national contexts [11]. Reviews of youth financial education identify experiential learning as promising while noting limited evidence on actual behavior [12]. Earlier synthesis found weak and decaying average relationships between financial education and downstream behavior [13], whereas a later meta-analysis of randomized experiments reported positive average causal effects on knowledge and

behavior [14]. These findings indicate that intervention design, timing, outcome definition, and evaluation horizon matter.

Direct studies illustrate both potential and limits. Research has examined a simulated stock-market microworld [15], a national randomized evaluation of the Stock Market Game [16], a controlled study of the Chair the Fed simulation [17], financial and numeracy practice within a business simulation [18], individual differences in financial game experience and interest [19], reflection prompts and perceived utility [20], and financial-literacy board games [21]. Critical analysis of stock-market games also warns that an apparently neutral rule system can carry assumptions about markets, responsibility, and desirable behavior [22]. This paper is a selective technical narrative review of design principles, applications, risks, assessment, and future directions. It presents no original experiment and excludes general generative-AI tutoring, which has been addressed separately.

2 TECHNICAL AND INSTRUCTIONAL FOUNDATIONS

2.1 From Financial Model to Interactive System

A financial simulation converts a conceptual model into an interactive state-transition system. At time t , the system contains a state such as cash, debt, assets, prices, demand, inflation, or unemployment. The learner selects an action, the scenario engine applies rules and possibly a stochastic shock, and the system produces a new state together with observable consequences. Constraints define feasible actions, while the clock determines whether decisions occur in days, months, quarters, or years. This architecture makes relationships visible through action rather than description.

The model should preserve the targeted relationship without unnecessary complexity. A diversification exercise needs correlated returns; a resilience exercise needs irregular expenses and liquidity constraints; and a monetary-policy simulation needs transmission lags. Elaborate graphics cannot compensate for a causal model that rewards the wrong principle.

2.2 The Decision–Feedback–Revision Loop

The central learning mechanism is a repeated decision loop. A learner interprets the current state, predicts consequences, chooses an action, receives system feedback, and revises a mental model before the next round. Repetition can expose path dependence: the same action may have different consequences after earlier borrowing, investment, or pricing decisions. Stochastic scenarios can also show that a sound process does not guarantee the best single outcome and that a lucky outcome does not validate a poor process.

Feedback must reveal more than rank or final wealth. Outcome feedback states what happened; process feedback identifies the influential decision; explanatory feedback connects it to a principle; and feed-forward guidance directs the next round. Immediate explanation can truncate productive reasoning, whereas opaque feedback allows misconceptions to persist. Scaffolding should decrease as learners become able to interpret financial evidence independently.

2.3 Goals, Rules, and Incentive Alignment

Game mechanics direct attention. Goals establish what counts as success, rules define possible strategies, and rewards make some actions more salient than others. If an investment game rewards only the highest short-term return, rational play may encourage concentration, turnover, and tail risk. If a personal-finance game measures only end-of-round cash, it may undervalue insurance, credit quality, emergency reserves, or long-term well-being. Mechanics should instead represent the target competence through balanced objectives, constraints, and consequences.

Motivational design must also account for heterogeneous learners. Choice can support autonomy, calibrated challenge can support competence, and team roles can support relatedness, but competition may discourage beginners or reward prior gaming familiarity. The same leaderboard can motivate one group and narrow another group's attention to score optimization. For this reason, motivational features should be treated as testable design components, not universal additions [5].

2.4 Debriefing and Transfer

Debriefing turns an event sequence into an explicit learning object. A structured session can ask learners to reconstruct what happened, identify the assumptions behind their choices, compare strategies, connect outcomes to financial concepts, examine the model's omissions, and apply the principle to a new case. This process is not an optional discussion added after the "real" activity; it is the stage at which experience is interpreted and potentially transferred [9].

Transfer should be designed rather than presumed. A near-transfer task may change the numbers while preserving the same financial structure. A farther-transfer task may change the product, institutional setting, time pressure, or information format [10]. Instructors can support transfer by varying scenarios, requesting explicit principles, removing familiar interface cues, and using delayed cases that cannot be solved by repeating a memorized game strategy.

Table 1 summarizes the principal design layers.

Table 1 Design Layers, Learning Functions, and Misalignment Risks in Finance Simulations and Games

Design layer	Technical implementation	Intended learning function	Failure when misaligned
Competency model	Observable knowledge, calculation, decision, and explanation targets	Defines what learners should demonstrate	Activity becomes engaging but educationally unfocused
Scenario engine	State variables, transition rules, time scale, uncertainty, and constraints	Makes financial relationships responsive to action	Simplification teaches an incorrect causal model
Action and reward system	Feasible choices, costs, objectives, penalties, and role permissions	Directs attention and supports strategy formation	Learners optimize the score rather than the competence
Feedback system	Outcome, process, explanatory, and feed-forward messages	Corrects misconceptions and guides subsequent practice	Feedback is either opaque or removes productive reasoning
Debriefing and transfer	Event replay, comparison, abstraction, model critique, and new cases	Converts experience into concepts usable elsewhere	In-game performance remains context-bound
Evidence layer	Event logs, calculations, explanations, tests, and delayed tasks	Supports diagnosis and evaluation	Clicks or final scores are mistaken for learning

3 APPLICATION SCENARIOS IN FINANCE EDUCATION

3.1 Personal Finance and Financial Resilience

Personal-finance games can compress years of income, budgeting, credit, saving, insurance, taxation, and shocks into repeated rounds. They expose opportunity cost and interdependence: high current consumption can create a later liquidity problem, while avoiding all borrowing may forgo a productive investment. The system can compare strategies without prescribing one universally optimal life choice.

Evidence in this area remains stronger for immediate outcomes than for durable behavior. One study reported associations between situational interest and learners' prior financial motivation, knowledge, and gaming experience [19]. A quasi-experiment found that strategic game mechanics combined with direct reflection prompts increased perceived utility, whereas changes in financial interest were group-independent and temporary [20]. A recent quasi-experimental study also reported immediate gains following financial-literacy board-game lessons [21]. These results support carefully designed practice, but they do not show that a short game alone changes long-term household behavior.

3.2 Investment and Market Learning

Market simulations allow learners to construct portfolios, trade under uncertainty, observe price changes, and calculate return and risk. The simulated transactional interactive concurrent system studied by Liu, Ho, and Chueh illustrates the use of a stock-market microworld for financial-literacy learning [15]. A large randomized evaluation of the Stock Market Game also reported gains in investor knowledge and mathematics achievement [16].

A sound investment simulation should include transaction costs, diversification, benchmark comparison, time horizon, and risk-adjusted performance. Repeated scenarios should distinguish skill from favorable market paths and should require learners to justify a portfolio before seeing the outcome. Instructors should explicitly discuss what the simulation omits, including liquidity constraints, taxes, product complexity, behavioral pressure, and rare losses. This is necessary because competitive short-horizon games can imply that frequent trading and winning against peers are the central purposes of investing [22].

3.3 Enterprise Finance and Accounting Integration

Business simulations connect operating choices with financial consequences. Teams may choose prices, production, marketing, inventory, staffing, capital expenditure, and financing; the system then updates demand, cost, profit, cash, debt, and statements. This structure helps learners see why a profitable firm can face a cash shortage or why growth can increase working-capital needs. It also supports role rotation among finance, accounting, operations, and management functions.

A quasi-experimental study of a marketing simulation found improvements in tested numeracy and financial performance but not in self-efficacy [18], illustrating why outcome measures should remain separate. In vocational undergraduate education, enterprise simulations can integrate spreadsheet analysis, budgeting, statement interpretation, variance analysis, and decision communication, provided that calculations and explanations remain visible rather than hidden behind a score.

3.4 Monetary Policy and System-Level Decisions

Policy simulations make feedback, lag, and uncertainty central. In Chair the Fed, players adjust an interest rate while observing inflation, unemployment, news, and shocks. A controlled study across high-school economics classes found higher posttest knowledge for classes using the simulation than for comparison activities [17]. The application demonstrates how a compact dynamic model can make an abstract transmission mechanism actionable.

The same principle can support bank-liquidity, payment-system, or financial-contagion scenarios, but more complex models require greater transparency. Learners should know which relationships are modeled, which are fixed, and where real institutions behave differently. Multiple roles can reveal conflicting objectives: a regulator, bank treasurer,

investor, and borrower may respond differently to the same shock. The educational purpose is to reason about trade-offs, not to discover a mechanically correct policy button.

4 OUTCOME-ALIGNED DESIGN AND ASSESSMENT

4.1 Begin with Demonstrable Competence

Design should begin with what the learner must demonstrate after the activity. A knowledge objective may require explaining compound interest; a procedural objective may require constructing a cash budget; a decision objective may require selecting and defending a financing mix under constraints. Each target needs corresponding evidence. If the objective is risk reasoning, final portfolio value is insufficient because it confounds strategy with the realized scenario path.

An operational sequence follows from this alignment. Define the competency and major misconceptions; specify the financial relationships the scenario must preserve; make them consequential through actions and rewards; design feedback and debriefing; select assessments beyond the game score; pilot for exploits, accessibility barriers, and unintended messages; and revise from learner errors and instructor observations.

4.2 Assess a Hierarchy of Outcomes

Assessment should distinguish reaction, process, knowledge, transfer, and behavior. Enjoyment, presence, and willingness to continue indicate acceptance but not mastery. In-game actions reveal strategy within the modeled environment. A posttest can measure concepts and calculations. A novel case tests whether the learner can apply the principle beyond the original interface. Delayed assessment or observed practice is needed before making claims about durable behavior.

This hierarchy is important because evidence varies by outcome. A review of youth financial education found more consistent short-term improvements in knowledge and attitudes than in observed behavior [12]. Meta-analyses also differ on the magnitude and persistence of downstream effects [13-14]. A simulation evaluation should therefore state exactly which level was measured and avoid using “financial literacy” as one undifferentiated result.

4.3 Use Process Data Cautiously

Digital environments can record each state, action, calculation, hint, revision, and explanation. These traces can reveal whether a learner diversified before or after a loss, noticed a liquidity warning, tested an alternative, or repeated an ineffective strategy. Process evidence is often more diagnostic than a final score because it preserves the path by which the outcome was produced.

Telemetry does not automatically create a valid assessment. Click frequency may reflect confusion, exploration, accessibility needs, or interface familiarity. Team logs may not identify who reasoned and who merely submitted the action. Models that infer competence from gameplay must be validated against independent tasks, checked across learner groups, and accompanied by explanations that instructors and students can inspect. High-stakes grades should not depend on an opaque behavioral score.

Table 2 links instructional phases with evidence.

Table 2 Instructional Phases, Supports, Evidence, and Interpretation in Finance Simulations and Games

Phase	Primary activity	Instructional support	Evidence retained	Appropriate interpretation
Before play	Diagnose prior knowledge and explain roles, rules, and model scope	Worked example, interface practice, accessibility options	Baseline task and readiness check	Starting condition, not ability label
During play	Make decisions across one or more scenario rounds	Calibrated hints, responsive feedback, optional replay	State-action history, calculations, explanations	Strategy and misconception evidence within the simulation
Debrief	Reconstruct events and compare strategies	Facilitated prompts, model critique, concept mapping	Decision rationale, error analysis, peer comparison	Evidence of reflection and conceptualization
Near transfer	Solve a structurally similar case with changed data	Reduced scaffolding	Independent calculation and justification	Application beyond memorized values
Farther and delayed transfer	Address a new product, institution, or time horizon	Minimal cues	Delayed case, project, or observed practice	Stronger but still context-bounded evidence of transfer

5 RISKS AND IMPLEMENTATION CHALLENGES

5.1 Engagement Is Not Learning

Games can increase attention and persistence, yet an enjoyable activity may produce weak conceptual change. Meta-analytic evidence is sensitive to comparison conditions: simulations appear less distinctive when comparison instruction also actively engages learners [7]. Learners may also become skilled at interface patterns without understanding the underlying finance. Evaluation should therefore include independent explanations and transfer tasks rather than satisfaction surveys alone.

5.2 Model Error and Hidden Curriculum

Every simulation is an argument about which variables and relationships matter. A deterministic credit game may imply that default follows only from poor individual choices; a market game may omit institutions, fees, or systemic risk; a business game may treat profit as the sole objective. Such omissions are sometimes necessary, but they become misleading when they remain invisible. Critical analysis of the Stock Market Game demonstrates why educators should examine the technical content of a simulation [22].

Simulation model documentation can specify learning objectives, rules, data sources, time scale, excluded mechanisms, valid uses, and known exploits. Debriefing should compare the simulated world with actual financial institutions, turning simplification from a hidden assumption into a topic for analysis.

5.3 Competition and Distorted Risk Taking

Competitive rankings can generate effort, but they can also privilege short-term variance. A learner trailing near the end may rationally take an extreme position because rank, rather than sound process, determines the reward. The resulting behavior is appropriate for the game but inappropriate as an investment lesson. Balanced scorecards, risk limits, multi-period evaluation, written rationale, and rewards for process quality can reduce this distortion.

Failure also requires careful framing. Costless replay supports experimentation, but repeated resets can make insolvency, debt, or policy failure appear trivial. Scenarios should preserve the analytical value of failure while using debriefing to discuss real consequences and ethical responsibilities. The objective is a psychologically safe environment, not a consequence-free conception of finance.

5.4 Equity, Accessibility, and Team Dynamics

Prior gaming experience, language, numeracy, device access, and product familiarity can affect performance independently of the intended competence. Fast interfaces and public leaderboards may disadvantage reflective learners or users of assistive technology. Inclusive design requires keyboard access, readable visuals, controllable speed, clear terminology, noncompetitive options, and low-bandwidth alternatives where necessary.

Team simulations add collaboration but can conceal unequal participation. Dominant members may control decisions while other students receive the same score. Rotating roles, individual forecasts before team discussion, decision rationales, and individual transfer tasks can preserve collaborative learning without surrendering assessment validity.

5.5 Data, Cost, and Instructor Capacity

Event logs may contain identifiable patterns, financial attitudes, performance profiles, and peer interactions. Collection should be limited to a stated educational purpose, with defined access, retention, and deletion rules. Students should know which actions are recorded and how the data affect feedback or grading. Commercial platforms require additional scrutiny of secondary data use and algorithm changes.

Simulations demand model maintenance, scenario authoring, support, and instructor preparation. A complex platform is not automatically preferable to a transparent spreadsheet, board game, or role play. Medium choice should follow the competency, update burden, available devices, and feedback needs; teacher preparation must cover both the financial model and debriefing.

6 FUTURE DIRECTIONS

6.1 Adaptive but Transparent Scenarios

Future systems can adjust difficulty, volatility, information load, or scaffolding from demonstrated performance. Adaptation should be bounded by an explicit competency map so that two learners are not silently assessed on incomparable tasks. The system should record why a scenario changed and allow instructors to inspect or override the rule. Adaptation is most defensible when it expands appropriate practice rather than manipulating engagement.

6.2 Explainable Learning Analytics

Learning analytics should move from descriptive dashboards toward interpretable diagnoses. Instead of reporting only time and score, a system might show that a learner repeatedly ignored scale, used nominal rather than real return, or relied on unstable short-term funding to finance long-term assets. Such claims require validated mappings between actions and concepts. Explanations should display the relevant event sequence and remain open to instructor correction.

6.3 Collaborative and Multi-Role Simulation

Networked simulations can represent negotiations and externalities that single-player systems omit. Learners can rotate among household, firm, bank, investor, auditor, and regulator roles, making information asymmetry and conflicting objectives visible. Future designs should compare individual and team reasoning, distinguish communication quality from outcome luck, and prevent social dynamics from becoming an unmeasured source of assessment bias.

6.4 Authentic Data in Controlled Sandboxes

Market, corporate, and macroeconomic data can increase relevance, but authentic data also introduce licensing, privacy, version, and hindsight problems. Reproducible data snapshots are preferable to a live feed when learners must receive comparable conditions. Synthetic or perturbed cases can protect sensitive information, provided that distributions, constraints, and rare events are validated for the educational purpose. Every scenario should retain its data version and model configuration.

6.5 Longitudinal and Transfer-Centered Evaluation

The most important evidence gap is not whether learners enjoy a simulation but whether they retain and appropriately transfer its lessons. Future studies should use active comparison conditions, preregistered outcomes, delayed tests, novel cases, and behavior measures where feasible. Results should be reported by prior knowledge, socioeconomic background, accessibility need, and gaming experience. This design would clarify for whom a particular mechanism works and whether short-term gains survive outside the game.

7 REVIEW LIMITATIONS

The discussion integrates selected evidence narratively, without systematic screening or meta-analytic estimation. It combines studies of serious games, gamification, computer-based simulation, business education, economics education, and financial literacy, whose interventions and outcome measures are not directly comparable. Several finance-specific studies measure immediate knowledge, interest, or performance in one platform; they do not establish durable real-world financial behavior. Evidence from school settings may not transfer unchanged to vocational undergraduate or professional education. No original game, learner dataset, experiment, effect estimate, or causal analysis is presented. The proposed design framework is a synthesis that requires local validation against learners, curricula, technology, and institutional policy.

8 CONCLUSION

Simulation-based and game-based learning can make financial relationships observable through decisions and consequences. A learner can test a budget against shocks, observe risk and diversification across market paths, connect enterprise choices to cash flow and statements, or experience monetary-policy lags. These environments are valuable because they organize deliberate practice around systems that are otherwise difficult, costly, or unsafe to experience directly.

Their educational value depends on alignment. The competency must determine the financial model; the model must determine meaningful actions and consequences; feedback must reveal mechanisms; debriefing must convert experience into explicit concepts; and assessment must test transfer beyond the game score. Competition, visual polish, and engagement cannot compensate for invalid rules or weak reflection. Future systems should use adaptation, analytics, collaboration, and authentic data only when those features remain transparent, accessible, and educationally justified. Properly designed simulations and games are not shortcuts to financial competence, but they can provide disciplined environments in which learners practice, explain, challenge, and revise financial decisions.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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