

GCC Education PPPs AI Enrolment Forecasts and Outcome Linked Payment Design

A Decision Framework for Demand Evidence Capacity Finance Performance Payments and Lender Protection

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Abstract

Background. Gulf education systems must plan school capacity while population, household location, migration, private-school participation and curriculum preferences change. Public private partnerships can mobilise design, construction, finance, maintenance and operating capability, yet weak demand evidence or an uncalibrated payment mechanism can create empty capacity, overcrowding, unaffordable commitments or disputed deductions. *Objective.* This paper develops a transaction framework that connects artificial intelligence supported enrolment forecasts with capacity decisions, project finance and outcome-linked payments for GCC education PPPs. *Approach.* It separates population evidence, catchment demand, school choice, physical availability, service performance and education outcomes. It then assigns each measure to a decision, owner, verification method and financial consequence. A hypothetical school-cluster case tests forecast ranges, a blended payment mechanism, lender coverage and downside responses. *Findings.* A useful enrolment forecast produces a range with traceable drivers and scheduled reconciliation rather than a single asserted number. The payment mechanism should protect service continuity, preserve lender bankability and create proportionate incentives for performance that the private party can influence. Learning outcomes require careful baselines, cohort adjustment, verification and safeguards against exclusion or teaching to the metric. *Implications.* Procuring authorities, sponsors, operators and lenders can use one evidence ledger from catchment planning through procurement, drawdown, operations and payment. The worked case is illustrative. It does not forecast an identified project, and every legal, demand, cost and performance assumption requires transaction-specific verification.

JEL Classification: G32, H52, H54, I22, C53

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1 Define the public service and the investment decision

An education PPP begins with a public-service decision. The authority may need additional seats in a fast-growing district, replacement of unsuitable buildings, specialist provision, lower whole-life facilities cost or a stronger operating model. Those needs lead to different contracts. A design-build-finance-maintain project transfers building delivery and lifecycle obligations. A broader contract may add non-core services or school operations. A voucher or service-purchase arrangement pays for eligible students in existing private capacity. The transaction team should state which service is being procured before it models enrolment or chooses a payment formula.

The unit of analysis must also be clear. A national student forecast is too broad for a school-cluster financing decision. A single address is too narrow when families can choose among public and private

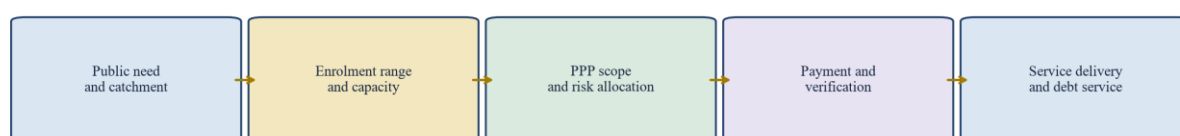
schools or move within a metropolitan area. The practical unit is a service package that connects defined catchments, age cohorts, planned seats, curriculum and inclusion requirements, land and utilities, delivery schedule, operating standards and the public payment obligation.

Saudi Arabia's National Center for Privatization reported the launch of a 60-school project in Madinah with a stated investment value of SAR 5.2 billion over 23 years.[1] Its project material describes school-infrastructure PPP delivery within the Kingdom's private-sector-participation programme.[2] Those facts establish a current regional precedent for long-term education infrastructure contracting. They do not establish the correct demand, value or payment structure for another jurisdiction or project.

Record the decision in terms that can be tested. The authority should identify the required opening date, grades, initial and ultimate capacity, service hours, student eligibility, transport assumptions, special-education obligations, curriculum, asset condition at handback and the party responsible for admissions. A lender needs the same perimeter because construction completion does not create repayment capacity unless the contract produces an enforceable payment after the school becomes available.

The Saudi Private Sector Participation Law provides a legal framework for PPP contracts and permits terms generally up to 30 years, subject to its provisions and approvals.[3] Current implementing rules and transaction documents require qualified legal review.[4] Across the GCC, each project remains subject to its own procurement, education, land, data, labour and financing rules. A regional framework can organise the decision while local counsel confirms the enforceable contract.

Figure 1. From public need and demand evidence to financeable education service



The investment case connects verified demand, contractual service and a payable performance obligation.

Proposed decision chain. Each stage requires an accountable owner, dated evidence and an explicit consequence.

Table 1. Decisions that precede the financing model

Decision	Evidence required	Failure condition	Transaction response
Why is capacity required	population, cohort, utilisation, condition and policy evidence	the need cannot be tied to a defined service area or period	pause procurement and rebuild the needs case
What service is transferred	output specification, responsibilities and interfaces	educational and asset obligations are mixed without accountable owners	redraw the service and interface schedule
How is the project paid	appropriation route, payment formula, indexation and deductions	payment depends on a measure the private party cannot control	reallocate risk and recalibrate the formula
What supports debt service	availability date, base payment, reserves and coverage	repayment relies on optimistic student volume or unverified outcomes	lower leverage or strengthen the fixed component
How does evidence change decisions	forecast refresh, inspection, audit and dispute route	new evidence has no contractual consequence	add review dates, thresholds and remedies

2 Separate infrastructure availability from education outcomes

Education projects combine assets, services and public policy. The school building can be available while attendance is below forecast. Facilities can meet technical standards while learning outcomes remain weak. Students can improve even when a maintenance defect exists. A single performance score would conceal these different causes and transfer risks without a clear owner.

Define four layers. The first is asset availability: safe access, classrooms, utilities, cooling, technology, hygiene, fire systems and accessible facilities. The second is service performance: cleaning, maintenance, security, catering, transport or other contracted services. The third is participation: eligible enrolment, attendance, retention and progression. The fourth is education outcome: learning, wellbeing, inclusion or another policy result. Each layer needs a baseline, measurement interval, verifier, cure period and payment treatment.

The World Bank PPP Reference Guide identifies performance-contingent payment as a defining feature and notes that the private party commonly operates through a dedicated project company.[5] Its payment-mechanism guidance distinguishes user charges, government payments, availability payments, milestone subsidies, bonuses, penalties and indexation.[6] These tools create different allocations of demand, performance and fiscal risk. The project should select a formula that follows the contracted responsibility.

An infrastructure-only private party normally cannot control admissions, curriculum, teacher deployment or household migration. Placing enrolment or learning risk on that party can make the contract unpriceable or create a premium without changing outcomes. An integrated operator may influence attendance and learning, but the authority still controls policy, standards and many admissions conditions. The contract should identify joint dependencies rather than assigning every result to the operator.

Outcome-linked payments require a stable base. Debt service, lifecycle maintenance and essential staff cannot depend entirely on a volatile annual test score. A substantial availability component supports continuity when the asset and required services are delivered. A smaller variable component can reward verified performance, subject to caps, floors, lag periods and protections for factors outside the operator's control.

The distinction also improves accountability. A building defect should trigger a timely service deduction and cure. A forecast miss should trigger capacity review. A learning shortfall should lead to diagnostic action using cohort and school evidence. Applying the same financial remedy to every variance can weaken service continuity and make disputes more likely.

3 Build an auditable enrolment evidence base

Enrolment begins with people, geography and choice. Start with population by single year of age or the narrowest available cohort, births, progression, migration, household formation and planned development. Add current school enrolment, grade capacity, utilisation, waiting lists, transfers, withdrawals, transport patterns, curriculum preferences, fees and private-school participation. Every variable should have a source, reference date, geographic level and known limitation.

Official statistics provide the anchor. Saudi Arabia's General Authority for Statistics publishes education and training indicators and population estimates.[16][17] The UAE Federal Competitiveness and Statistics Centre publishes population and general-education series, while the UAE open-data platform provides a Ministry of Education enrolment dataset classified by zone, sex, school type, stage and year.[18][19] Qatar's Ministry of Education and Higher Education publishes annual statistics covering schools, students, teachers and administrators, and reported 419,373 students across 649 public and private schools and

kindergartens for the 2026 to 2027 school year.[20][21] GCC-Stat provides regional education and student databases by stage, gender, sector, nationality and other dimensions.[22]

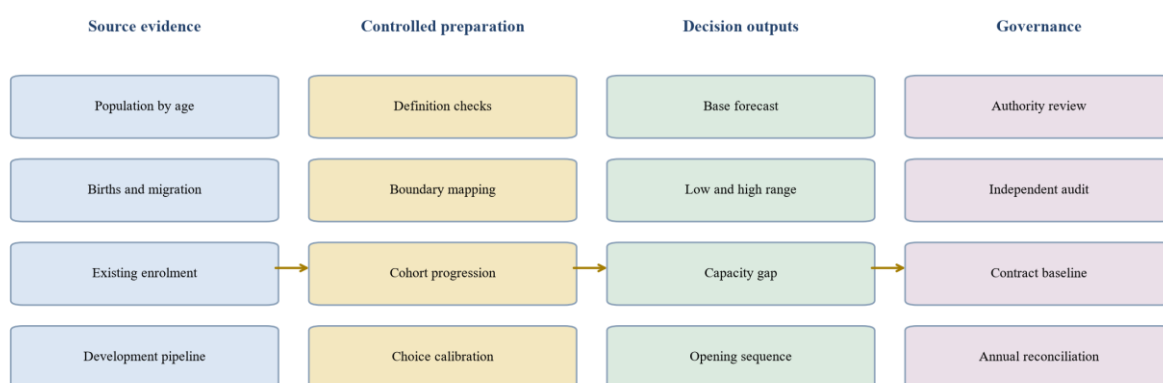
These sources use different definitions, periods and coverage. Academic-year data may not align with calendar-year population estimates. A school address may represent a campus while students travel from several municipalities. Private-school records may classify nationality, curriculum or stage differently from public records. The evidence ledger should preserve the original definition and document every transformation.

Catchment evidence should be practical. Use travel time, road access, public transport, school-bus routes, development phasing and natural barriers rather than a simple radius. Record approved and proposed schools separately. A planned development contributes students only after occupation. A announced school removes pressure only after it opens with the relevant grades and admission policy.

Reconcile stock and flow. Current enrolment is a stock. Births, grade progression, in-migration, out-migration, transfers, repeating and dropout create flows. A coherent model should explain the movement from one academic year to the next. Large unexplained residuals indicate inconsistent sources, boundary changes or omitted behaviour.

The UNESCO Institute for Statistics describes an education management information system as the people, technology, models, rules and processes used to support planning and management. Its guidance emphasises complete, relevant, accurate, timely and accessible data.[11][12][13] The forecast should therefore carry data-quality controls as part of the transaction evidence, rather than treating source preparation as a technical prelude.

Figure 2. Governed enrolment forecast architecture



Every output retains its source period, definition, transformation, model version and approver.

Proposed evidence flow from official records and local observations to forecast ranges and decisions.

Table 2. Minimum enrolment evidence register

Evidence group	Example measure	Control	Refresh trigger
population	residents by single year of age and locality	retain official release, geography and estimate status	new census, estimate or boundary
cohort flow	births, grade progression, repetition and migration	reconcile start and end populations	academic-year close or policy change
school capacity	seats, grades, utilisation and condition	verify operating and planned capacity separately	opening, closure or refurbishment
school choice	public and private shares, curriculum and fees	calibrate with observed applications and transfers	fee, admission or curriculum change

Evidence group	Example measure	Control	Refresh trigger
development	dwellings, delivery dates and household assumptions	use approved phasing and occupancy evidence	delay, redesign or occupancy evidence
model output	base, low and high enrolment and capacity gap	version, sensitivity and approval record	forecast error or decisive input change

The register allows a reviewer to reconstruct the forecast and test a later update.

4 Produce ranges that a transaction committee can understand

Artificial intelligence can help detect patterns, combine high-dimensional inputs and update forecasts. The transaction committee still needs an understandable model. Begin with a transparent cohort progression baseline. Apply observed progression, migration and participation assumptions to each age group. Then use statistical or machine-learning methods where they add measurable predictive value.

Separate structural drivers from short-term signals. Population age structure and committed housing influence capacity over several years. Applications, transfers, transport registrations or web enquiries may improve a near-term update. A short-term signal should not rewrite the long-range demographic path without evidence. Record which horizon each variable supports.

Use a training period, validation period and genuine holdout where the data permit. Compare the AI model with simple benchmarks such as last-year carry-forward, cohort survival and a trend model. A complex model earns influence only when its out-of-sample error, stability and decision usefulness exceed those benchmarks. Preserve poor years and policy breaks rather than selecting only stable periods.

Forecast uncertainty belongs in the decision. Produce low, base and high paths and show the drivers that move the result. The range should reflect parameter uncertainty, migration, housing delivery, participation and model error. A narrow range created by a precise algorithm can be misleading when the underlying population estimate or development schedule remains uncertain.

Explainability should fit the use. A planner may need locality, age and school-type contributions. A procurement committee needs the effect on seats, phasing and affordability. A lender needs the effect on payment, coverage and reserves. The model file should allow each reviewer to trace the decision without exposing personal student records.

The UNESCO Recommendation on the Ethics of Artificial Intelligence calls for transparency, fairness, privacy, auditability and human oversight.[14] UNESCO's education guidance warns that learner prediction raises ethical and data-protection concerns.[15] Enrolment planning should use the least sensitive data needed, test uneven errors across locations or groups and retain accountable human approval.

Table 3. Forecast validation for an education PPP

Test	Question	Evidence	Decision consequence
benchmark	does the model improve on cohort and trend baselines	out-of-sample error by horizon	reject complexity without measured gain
calibration	do forecast ranges contain observed enrolment at the stated rate	interval coverage and residual plots	widen or recalibrate uncertainty
stability	does a small data change create an excessive capacity change	sensitivity and version comparison	cap decision influence and investigate
subgroup error	are misses concentrated by locality, stage or school type	segmented error measures	revise data, features or allocation rule

Test	Question	Evidence	Decision consequence
drift	have population, choice or development relationships changed	monitored input and residual drift	trigger controlled retraining
auditability	can a reviewer reproduce the approved forecast	sources, code, parameters and sign-off	withhold procurement or payment use

Measures should be reported by relevant locality, stage and forecast horizon.

5 Translate enrolment ranges into a capacity programme

A forecast becomes useful when it changes a capacity decision. Convert students into required teaching spaces using class-size policy, grade configuration, inclusion needs, specialist rooms, timetabling and operational utilisation. Nominal seats can overstate practical capacity when laboratories, sports areas, accessibility or staff facilities constrain the programme.

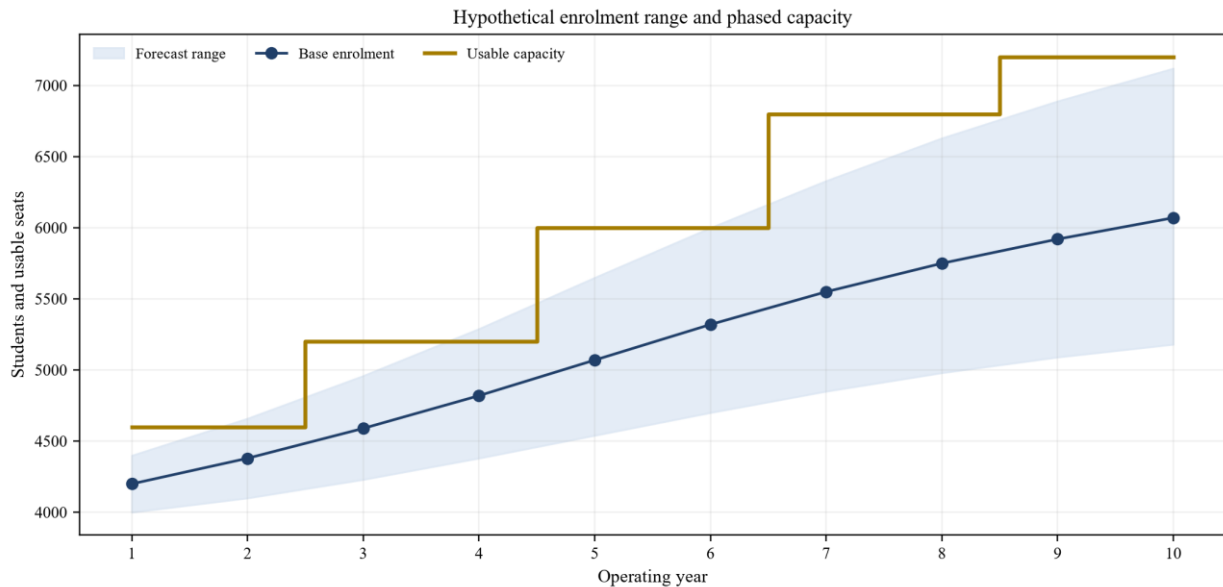
Map the base, low and high paths against usable capacity by year and catchment. Identify the date when existing capacity reaches the agreed utilisation ceiling. Test whether temporary classrooms, transport, boundary changes, extensions or private-school purchases can bridge a short gap. A new PPP school is appropriate only when the need survives credible lower-cost responses and persists for enough years to support its fixed cost.

Stage capacity where uncertainty is high. A school can open with a subset of grades, reserve expansion land or use modular space that meets standards. A cluster contract can sequence sites when actual enrolment confirms demand. The flexibility has a price and should be valued against the expected cost of unused capacity or emergency expansion.

Land and access must match the forecast. A high-demand catchment does not make an unsuitable site deliverable. Verify title, permitted use, utilities, transport, safe access, environmental conditions, construction constraints and surrounding development. The opening sequence should reflect land readiness and procurement duration as well as student need.

The affordability model should preserve the full range. Capital cost, operating cost and lifecycle maintenance follow the chosen capacity. Public payments may continue for two decades or more. A decision based only on the base forecast can conceal fiscal exposure in the low case and service failure in the high case.

Figure 3. Hypothetical enrolment range and planned capacity



Values are modelling assumptions for an illustrative school cluster and do not represent an identified authority or project.

6 Build the project company and funding plan around the service

The financing structure should follow the contracted service and its cash flows. A project company can hold the PPP agreement, construction contracts, facilities-management agreements, insurance and debt. Sponsors provide equity and contingent support. Lenders fund eligible capital expenditure subject to conditions and progress. The authority begins periodic payments after acceptance, subject to the contract.

Define the perimeter before calculating leverage. Identify land rights, design responsibility, construction scope, technology, furniture, transport, facilities services, teaching services, lifecycle obligations and handback requirements. Costs outside the project company still affect value for money and affordability. A low project-company price can transfer unfunded interface costs back to the authority.

Match debt tenor and amortisation to the payment profile. Construction debt converts after completion and acceptance. Operating-period debt service relies on the contracted base payment, indexation, reserves and permitted deductions. Lenders should test the legal route from appropriation and invoice approval to cash receipt. A payment that is contractually due but routinely delayed creates liquidity risk.

Use reserves for defined risks. A debt-service reserve protects timing. A lifecycle reserve funds predictable major maintenance. A change-in-law or insurance mechanism addresses specific events subject to the contract. Reserves should not conceal an underpriced service or an aggressive demand assumption. Their size should reflect cash-flow timing and stress evidence.

Construction and operation interfaces deserve direct controls. The builder may complete the asset, while an operator must mobilise staff, systems, safeguarding and services before opening. Acceptance should include commissioning, licences, safety, accessibility, technology and operating readiness. Delay damages should align with the authority's lost service and the project company's financing exposure.

Funding flexibility can support phased capacity. A committed facility may have site or phase draw conditions. The borrower should demonstrate land readiness, approved design, budget, equity and remaining cost before each draw. Undrawn commitments should expire or reprice if the forecast or programme changes materially.

Table 4. Funding structure and evidence requirements

Funding element	Primary repayment or protection	Required evidence	Typical control
sponsor equity	residual project value	committed funds and source verification	equity first or agreed pro rata contribution
construction debt	future availability payment	fixed-price scope, programme, contingency and security	certified progress and cost-to-complete test
operating debt	contracted base payment	acceptance, invoice route, deductions and indexation	coverage covenant and debt-service reserve
lifecycle reserve	scheduled asset renewal	condition plan and cost profile	funded account with permitted uses
expansion facility	verified additional capacity need	refreshed forecast, land, approvals and affordability	phase-specific draw conditions
public support	policy objective or affordability gap	legal authority, budget and measurable purpose	milestone or output-based release

The allocation is illustrative and requires project-specific legal and credit analysis.

7 Design a blended payment mechanism

The payment mechanism converts service into cash. Begin with the payment objective. The authority may pay for asset availability, required services, occupied places, verified participation or education outcomes. Each component should correspond to a responsibility and avoid paying twice for the same result.

A practical structure has three layers. The base availability payment covers the financed asset, lifecycle maintenance and essential contracted services when the required capacity is available. A volume component can cover genuinely variable costs associated with eligible students. A capped outcome component can reward defined improvements or apply proportionate deductions for performance within the operator's control.

Calibrate the base component against bankability. The World Bank notes that availability payments are conditional on an asset or service being available to a specified quality, while usage-based payments transfer or share demand risk.[6] An education project with public admissions and volatile migration should normally avoid placing all debt service on student volume. The fixed component can decline for unavailable spaces or serious service failure without exposing the project to unrelated demand swings.

Define availability precisely. A classroom is not available if it fails safety, cooling, access or required technology standards. The contract should specify measurement, response time, rectification and the effect of partial unavailability. Deductions need caps and ratchets. Repeated or serious failures can escalate while an isolated minor defect receives a proportionate response.

The volume component should reflect marginal cost rather than total fixed cost. If catering, consumables or transport vary with student numbers, an agreed per-student or activity amount may be appropriate. The formula should define eligibility, count date, mid-year movements, duplicates, special provision and audit rights.

Outcome payments need a smaller, carefully controlled role. Results-based financing rewards agreed outputs or outcomes after verification.[9][10] In education, causation is shared and measurement can lag. Use a balanced set of leading and outcome measures, delay financial consequences until data quality is established and cap exposure to protect service continuity.

Indexation should match cost drivers. Labour, utilities and maintenance may move differently. A single consumer-price index can leave one party exposed to a cost it cannot control. The contract should specify indices, weights, floors, caps, rebasing and the treatment of discontinued series.

Figure 4. Proposed education PPP payment waterfall



Each adjustment has a definition, data source, verifier, cure period, cap and dispute route.

Illustrative structure. Percentages and deductions require affordability, value-for-money and lender calibration.

Table 5. Payment component design

Component	Example basis	Principal risk owner	Protection against distortion
availability	compliant usable capacity during required hours	project company	clear exclusions, cure periods and calibrated deductions
service performance	maintenance, cleaning, security and response times	relevant service provider	independent inspection and severity weighting
eligible volume	verified students or service units tied to variable cost	shared according to admissions control	count rules, audit and payment cap
participation	attendance, retention or progression	shared among authority, operator and households	adjusted baseline and contextual review
learning outcome	verified cohort measure	shared, with operator influence defined	multiple measures, lag, floor and capped adjustment
indexation	published cost indices and agreed weights	allocated by cost category	transparent formula, cap and rebasing rule

The design connects the measure to the party that can manage it and the cash consequence.

8 Select outcomes that support the service rather than the metric

An outcome measure should express a public objective and remain close enough to contracted activity for accountability. Candidate measures include attendance, retention, progression, learning gain, wellbeing, safeguarding, inclusion, parent experience and post-school transition. The final set should be small enough to govern and broad enough to avoid a single distorted target.

Define the result chain. Inputs such as staff and technology support processes such as teaching, maintenance or student support. Processes produce intermediate results including attendance or timely intervention. Longer-term outcomes include learning and progression. A payment formula can use several points in the chain while avoiding duplicate rewards.

Use value-added or growth measures carefully. Raw attainment reflects prior learning, household circumstances, language and student selection. A baseline-adjusted measure may improve comparability,

but the adjustment model introduces assumptions. Preserve the raw result, baseline, exclusions and model version. Do not allow the adjustment to hide a fall in absolute performance.

The operator should influence the measure. An infrastructure provider cannot reasonably bear curriculum outcome risk. An integrated school operator may influence attendance and learning, subject to authority policy and cohort composition. Joint measures can use a gain-share pool or require joint remediation instead of automatic deduction.

Guard against exclusion. A high-stakes metric can create incentives to avoid students who need more support, reclassify absences or narrow instruction. Monitor admissions, withdrawals, special-needs provision, language support and assessment participation. A result should not attract payment when it is achieved by reducing access or changing the measured cohort improperly.

Verification needs timing and materiality. Attendance can be reported frequently. Standardised learning outcomes may arrive annually and require moderation. Wellbeing evidence may be survey based and sensitive to response rates. The payment model should reflect each data cycle and avoid cash shocks based on late or unstable evidence.

World Bank guidance on education PPPs emphasises accountability, parental information, system capacity and rigorous evaluation.[8] Its results-based financing material distinguishes input, process, intermediate and outcome indicators and stresses verification.[10] A transaction can therefore combine reliable leading measures with a restrained, verified outcome component.

9 Create an independent evidence and verification system

The same data should not be collected separately for planning, operations, payment and policy if one governed record can serve each purpose. Build an evidence dictionary that defines student counts, availability, attendance, service incidents, learning measures, exclusions and reporting periods. Assign an owner and source system to every field.

Integrate the education management information system, project-company records, facilities-management system, finance ledger and independent-verifier evidence through controlled interfaces. Use stable identifiers where lawful and necessary. Reconcile aggregate counts across systems. A payment certificate should trace each adjustment back to a dated record and contract rule.

UNESCO's EMIS guidance calls for standard definitions, data naming conventions, quality requirements and processes to detect, correct and prevent nonconformity.[12] Its recent EMIS assessment tool treats institutional capacity and management processes as part of data-driven decision-making.[11] The PPP should fund these operating controls, since poor data can interrupt payment and weaken public accountability.

Independent verification should be risk based. Routine availability data may be system generated and sampled. Serious incidents, learning measures and contested deductions may require direct review. The verifier's appointment, competence, access, independence, timetable and liability should be documented. The authority and project company need a clear route to challenge an error without delaying every undisputed amount.

Freeze the evidence used for each payment cycle. Later corrections should create a controlled adjustment with an audit trail. Do not overwrite the original record. Preserve data, model version, approval, calculation and communication. Lenders may require access to payment certificates and material disputes while respecting student privacy.

Set data-quality thresholds. Missing records, duplicate students, unexplained movements or stale facilities data should trigger investigation. The financial treatment should distinguish data failure from service

failure. A reporting breach may require a temporary hold or estimate, followed by reconciliation, while an actual service breach follows the deduction regime.

10 Stress the forecast payment and financing together

Separate stress tests can miss the interaction among demand, costs, deductions and debt. Build one model that carries the enrolment range into capacity, payment, operating cost, lifecycle funding and debt service. The committee should see which risk changes cash and which risk changes only the public-service outcome.

Test low and high enrolment. Low enrolment can create unused capacity and weaken a usage-based payment. High enrolment can require temporary provision, accelerate expansion and increase variable service costs. Where the base availability payment remains fixed, demand risk affects public value and capacity decisions even if lender coverage is stable.

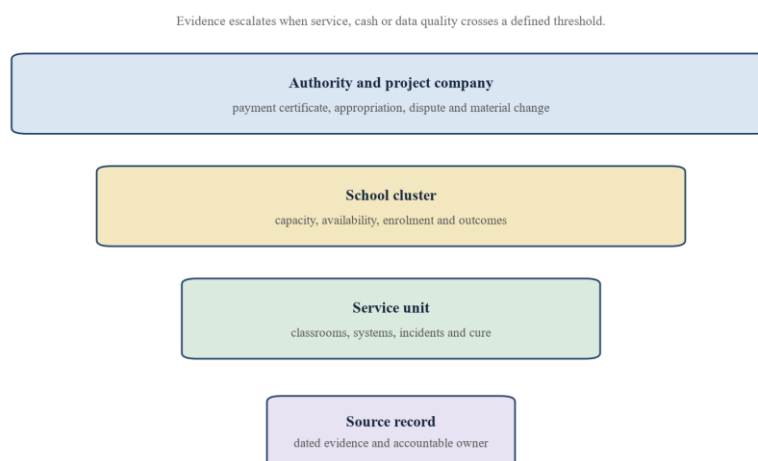
Test construction delay and acceptance failure. Debt capitalises for longer, sponsor support may be consumed and the payment start moves. Test operating deductions for unavailable classrooms, utilities or maintenance. Apply realistic cure periods and caps. A scenario with every maximum deduction at once may be less useful than a sequence based on plausible incidents.

Test outcome underperformance separately. A capped variable component should reduce cash within the agreed exposure without interrupting essential service. If a modest learning miss causes default, the payment design has transferred more risk than the financing can absorb. The remedy may be a lower variable share, a lagged rolling measure or a funded performance reserve.

Inflation and refinancing also matter. Labour and utility inflation can compress service margins. Interest-rate or refinancing exposure can weaken coverage even when operational performance is stable. Test index timing, caps, hedging, reserve draw and distribution lock-up.

Set decision rules before reading the final result. Define minimum coverage, maximum deduction exposure, reserve months, forecast range, capacity utilisation and equity contingency. The model should show the action when a threshold fails: reduce debt, increase equity, rephase capacity, alter payment weights, strengthen reserves or change scope.

Figure 5. Proposed covenant and early warning hierarchy



Controls escalate from school and service evidence to project-company liquidity and authority payment.

Table 6. Illustrative lender and authority dashboard

Level	Measure	Illustrative warning signal	Response
catchment	enrolment forecast error	actual outside approved range for two counts	refresh model and capacity plan
school	usable capacity	below 98 percent during required hours	cure plan and availability deduction
service	unresolved critical incidents	event remains open beyond response time	escalation and enhanced inspection
outcome	adjusted performance index	below baseline floor for two cycles	diagnostic review and capped payment adjustment
project company	debt service coverage	projected below agreed lock-up level	stop distributions and fund remedy
project company	liquidity reserve	below required months of outflow	replenish before discretionary payment
authority	certified payment delay	undisputed amount exceeds due date	liquidity protocol and contractual remedy

Thresholds are modelling assumptions and require project-specific calibration.

11 Work through a hypothetical GCC school cluster

Consider a hypothetical authority planning four schools in two growing metropolitan catchments. The case is a financing illustration. It does not describe an existing procurement, authority, operator or borrower. Monetary values, capacity, forecast paths, costs and payment terms are modelling assumptions.

The existing public and private estate serves 4,050 eligible students in the defined service areas. Current usable capacity is 4,300 seats, with several buildings approaching the authority's utilisation threshold. The evidence base includes population by age, historical enrolment, grade progression, housing delivery, public-private participation, transfer patterns and verified school capacity. The base forecast reaches 5,320 students by operating year six. The low case reaches 4,700 and the high case reaches 6,000.

The authority chooses a phased programme. Two schools provide 900 seats at the first service commencement date. A third phase adds 800 seats in year three, and the fourth adds 800 seats in year five. This produces the illustrative capacity path shown in Figure 3. Expansion is subject to land readiness, an updated enrolment range and affordability approval. The design preserves expansion space without obliging the authority to fund every phase at financial close.

Assume initial eligible capital cost of SAR 720 million for the first two phases. Sponsors fund 20 percent and senior debt funds 80 percent, subject to certified construction progress and a cost-to-complete test. The model assumes a separate lifecycle reserve and a six-month debt-service reserve at completion. These figures are assumptions and require current market testing.

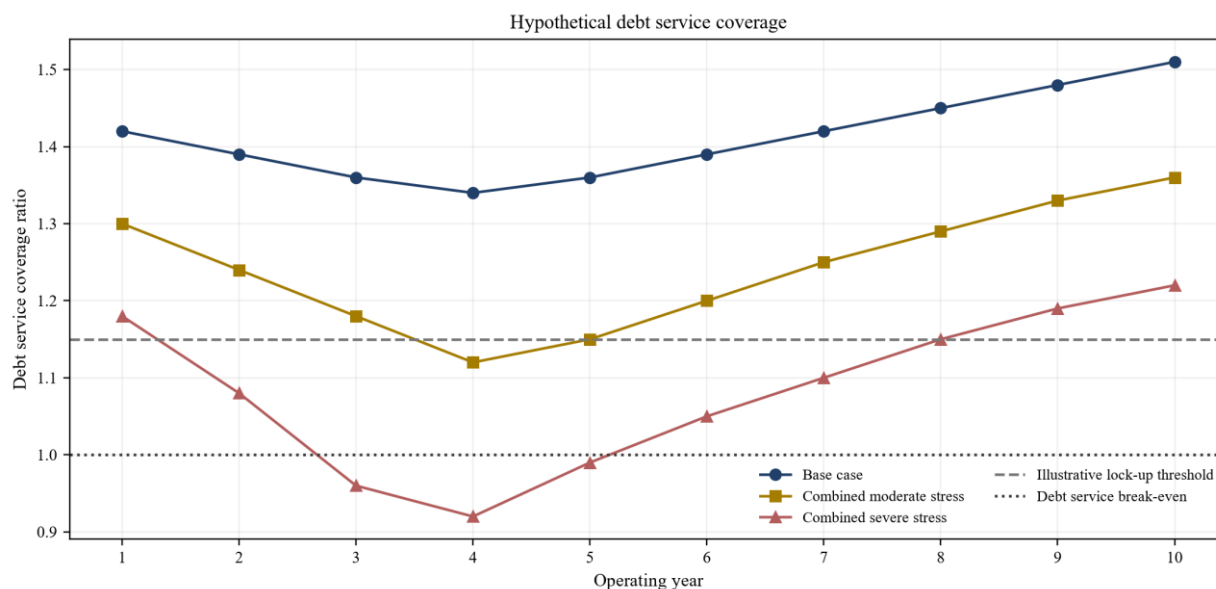
The annual payment has a base availability component equal to 86 percent of the maximum contracted payment, a volume component of 8 percent and an outcome pool of 6 percent. The base payment begins only after acceptance and is subject to service deductions. The volume amount pays defined marginal costs for eligible students within a band. The outcome pool uses attendance, retention, inclusion and learning-gain measures with individual caps and a combined floor.

The base case produces minimum modelled debt-service coverage of 1.34 times after stabilisation. A combined stress applies a six-month delay to the third phase, enrolment at the low path, operating cost 8 percent above the base, service deductions equal to 2 percent of gross payment and half of the outcome pool. Minimum coverage falls to 1.12 times and triggers a distribution lock-up under the illustrative covenant. The reserve remains above three months of debt service.

A more severe scenario combines a twelve-month delay, prolonged cost inflation, a 5 percent availability deduction and no outcome payment. Coverage falls below 1.0 times in one period. The model indicates that the initial leverage is too high if the committee considers this scenario plausible without additional support. Possible responses include more equity, lower debt, a larger reserve, reduced phase scope, stronger delay protection or a greater fixed payment share.

The high-enrolment case creates a different problem. Payment coverage improves only where the volume component reimburses variable service cost. Physical utilisation exceeds the operational threshold before the planned fourth phase opens. The authority therefore needs a temporary-capacity or accelerated-expansion decision. Lender protection alone does not resolve the public-service constraint.

Figure 6. Hypothetical debt service coverage under combined stresses



Values are modelling assumptions for an illustrative education PPP and do not represent an identified transaction.

12 Connect covenants to management action

A covenant should provide time for a response. Financial covenants alone may identify a problem after service or liquidity has weakened. Combine leading evidence, operating performance and cash measures. Each threshold needs a calculation, source, reporting date, owner and agreed consequence.

Forecast controls include actual enrolment against the approved range, application conversion, transfers and housing delivery. Capacity controls include utilisation, unavailable spaces and expansion milestones. Service controls include critical incidents, response time and repeat failure. Payment controls include certification, deductions, disputed amounts and days to cash. Financial controls include debt-service coverage, reserves, cost-to-complete and distributions.

Use cure and escalation. A forecast miss can require model refresh and a capacity review. Repeated asset unavailability can increase inspection and deductions. A projected coverage breach can stop distributions and require a remedial plan. An actual payment dispute can trigger the contractual resolution process while undisputed amounts continue.

Avoid automatic default from a model update. A forecast is decision evidence rather than an observable payment event. The covenant should respond when the update affects affordability, phase necessity or cash coverage beyond an agreed threshold. Management and the authority should retain documented judgement within the contract.

Aggregate indicators should not conceal school-level failure. Report each school and the cluster. A strong site can offset cash weakness elsewhere, but it should not erase safeguarding or availability breaches. Material incidents may require direct escalation regardless of portfolio averages.

Link distributions to evidence quality. The project company should not distribute cash when required reports are missing, a material dispute is unresolved or reserves are below the agreed level. This aligns sponsor cash extraction with continued service and lender protection.

13 Sequence diligence procurement and financial close

Start with the needs case. Confirm policy objectives, catchments, current capacity, estate condition, demand evidence and alternative delivery options. Record which assumptions are observed, estimated or subject to approval. A procurement timetable built on unresolved land or demand can create bidder cost without a financeable project.

Build a reference forecast and allow bidders to test it. Provide definitions, historical series, known developments, school capacity and data limitations through a controlled data room. State whether the authority retains demand risk and how future forecast updates affect phasing or payment. Bidders should not be asked to price an undefined risk.

Develop the output specification and payment mechanism together. Availability standards, service levels, reporting, deductions, volume bands and outcome measures should map to the financial model. Calibrate the formula under ordinary variance and combined stress. Seek market feedback without changing core risk silently between procurement stages.

During bid evaluation, separate price, financing, technical deliverability, service performance, data capability and contractual compliance. A low price supported by aggressive enrolment, weak lifecycle funding or inaccessible data is not comparable with a fully funded bid. Normalise assumptions or make the difference explicit.

Complete diligence on the project company, sponsors, builder, facilities manager, education operator and critical technology vendors. Review experience, capacity, conflicts, subcontracting, insurance, cyber controls, data rights and financial resilience. Confirm that the proposed responsibilities in the model match signed contracts.

Before financial close, freeze the base case, forecast version, output specification, payment formula, indexation, construction programme, lifecycle plan, reserve requirements and reporting dictionary. Execute direct agreements, security, step-in and cure provisions as required. The lender's technical, legal, insurance and model reviews should close against the same transaction documents.

Before each phase, refresh the forecast and affordability case using the agreed governance process. Expansion approval should remain a human committee decision supported by evidence. The project should retain the option to defer, resize or redesign a phase when demand or land evidence changes.

14 Govern AI data privacy and model change

Education data can include children, families, disability, attendance, assessment, location and behaviour. A forecast can often operate on aggregate cohort and catchment data. The project should use personal data only when lawful, necessary and proportionate. Local data-protection requirements and education-sector rules require qualified advice in each jurisdiction.

Define the model's approved purpose. A tool built for catchment capacity should not be reused to judge individual admissions, student ability or teacher performance without a separate legal, ethical and technical assessment. Purpose boundaries should appear in the data inventory, access controls and user guidance.

Minimise and separate data. Keep identifiers outside the modelling environment where practical. Use aggregated, pseudonymised or de-identified records with documented re-identification risk. Limit access by role, log use, encrypt transfers and define retention. A vendor should not receive broader student data because its platform offers additional features.

Test representativeness and error. Forecast accuracy may vary where migration, informal housing, small cohorts or private-school records are incomplete. Report error by locality and relevant group where lawful. Investigate whether a systematic underforecast would deprive an area of capacity or a systematic overforecast would lock public funds into unused assets.

Preserve human responsibility. UNESCO's AI ethics recommendation states that AI should remain auditable and traceable and should not displace ultimate human responsibility.[14] The transaction should identify who approves data, model, forecast, capacity and payment. Committee minutes should record overrides and reasons.

Control model change. Store code, data schema, parameters, training period, validation evidence and approved output. A change in algorithm, feature, boundary or source can alter the decision even when the headline forecast moves little. Classify material changes, require independent review where appropriate and retain the prior version for reproduction.

Plan for vendor exit. The authority should retain usable data, documentation and the right to operate or replace the model. Proprietary software can support the process, but the public service should not depend on an inaccessible score. Contractual exit assistance, export formats and continuity testing belong in procurement.

Table 7. Model and data control register

Control	Evidence	Owner	Escalation condition
approved purpose	documented capacity and payment use	authority model owner	use expands beyond approved decision
data lineage	source, period, definition, licence and transformation	data owner	decisive field is missing, stale or untraceable
validation	benchmark, range coverage, subgroup error and stress	independent reviewer	performance falls outside approved tolerance
change control	version, reason, test and approval	model committee	material feature, method or boundary changes
human decision	recommendation, override, evidence and approver	transaction committee	automated output determines capacity or payment alone
continuity	export, documentation, access and replacement test	technology owner	vendor or service becomes unavailable

The control applies from planning through operations and payment review.

15 Conclusion

An education PPP is financeable when public need, deliverable capacity, contractual service and payment evidence connect. The enrolment forecast informs that chain. It does not replace policy judgement, procurement discipline or independent verification.

The forecast should begin with official population and education evidence, preserve definitions and produce low, base and high paths. The capacity programme should respond through phasing and explicit alternatives. A model gains decision weight only when it improves on transparent benchmarks, reports uncertainty and remains reproducible.

The payment mechanism should distinguish asset availability, service performance, student volume and education outcomes. A stable base payment supports continuity and debt service. Variable and outcome components can create useful incentives when measures are controllable, verified, capped and protected against exclusion or gaming.

The transaction model should test forecast, cost, deduction and financing risks together. Covenants should trigger investigation, remediation, distribution control or phase review before liquidity fails. Independent evidence and a defined dispute route support both public accountability and lender confidence.

The hypothetical case illustrates how a moderate combined stress can reduce coverage to an illustrative lock-up level, while a severe combined stress can create a funding shortfall. The result does not predict a live project. It shows why leverage, reserves, payment weights and phasing must be calibrated against evidence.

The most durable control is reconciliation. Actual enrolment should update the forecast. Actual service should update payment. Actual costs and deductions should update finance. Each update should retain its source, model version, reviewer and decision. That process allows the authority, sponsors, operators and lenders to adapt while preserving responsibility for the public service.

Limitations and further research

This paper does not determine whether a particular education PPP provides value for money, complies with local law or should proceed. Project documents, land, policy, population, enrolment, construction, operating cost, finance and outcome evidence require transaction-specific verification. The illustrative case does not use a live authority's confidential data.

The relationship between school inputs and learning outcomes is complex. An observed association does not prove that one contracted service caused the result. Outcome payments should reflect this limitation. Further research could compare forecast accuracy across GCC metropolitan areas, assess the effect of private-school choice on public capacity, test payment calibration using actual deduction histories and evaluate whether phased capacity reduces whole-life public cost.

Research should also examine data coverage and fairness. Aggregate forecasts can still allocate capacity unevenly when source systems omit mobile or vulnerable populations. Independent evaluation could test subgroup error, access, admissions and service quality without exposing individual student records.

Frequently asked questions

Q: What should an education PPP enrolment forecast decide? | A: It should support a defined capacity, phasing, affordability or payment decision. It should state the catchment, grades, horizon, low, base and high paths and the action associated with each path.

Q: Should the private party bear enrolment risk? | A: Risk should follow control. An infrastructure provider usually cannot control admissions, migration or public policy. A volume component may cover variable cost, while the contract allocates residual demand risk explicitly.

Q: Can artificial intelligence replace a cohort forecast? | A: An AI model can add predictive value when it performs better than transparent benchmarks and passes stability, subgroup and audit tests. The authority should retain an understandable cohort baseline and human approval.

Q: How should availability payments relate to outcomes? | A: The availability component should fund the compliant asset and essential service. A smaller capped component can address verified outcomes that the operator can influence without threatening service continuity.

Q: Which education outcomes can support payment? | A: Attendance, retention, inclusion, learning gain and other measures may be used when the contract defines baselines, cohort treatment, verification, caps and protections against exclusion or gaming.

Q: How should forecast error affect the contract? | A: A material miss should trigger model review, capacity reassessment and any agreed phase decision. It should not create automatic default unless the contract ties the error to a defined cash or service threshold.

Q: What evidence do lenders need? | A: Lenders need the enforceable payment route, acceptance conditions, deduction exposure, construction and lifecycle funding, reserves, coverage, material disputes and access to verified payment evidence.

Q: How should student data be protected? | A: Use the least sensitive data needed, prefer aggregate or de-identified records, apply local law, restrict access, document purpose and retention, test bias and keep accountable human decision makers.

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