DYNAMIC QR AND GEOFENCE ATTENDANCE FOR LMS AND HEMIS: DESIGN, MARKET ANALYSIS AND SIMULATION

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Abstract. *Background. Paper rollcall takes class time and is easy to falsify. In March 2026 HEMIS, the national higher-education platform of Uzbekistan, added automatic attendance based on a dynamic QR code, but its documentation does not say whether location or time limits are checked. Objective. We examine how a teacher-controlled attendance layer (rotating QR code on the board, a location check, and a configurable scan window) can be added to an LMS or HEMIS, and how reliably the location check separates present from absent students. Methods.*

We compared seven solutions (four products, two research prototypes and the proposed design) on six documented security and control features and ran a Monte Carlo simulation (200,000 draws per condition) of a geofence under smartphone location errors taken from published measurements. Results. No solution we reviewed documents all six controls; the proposed design covers all six, from 1.0 to 2.0 of 6 for the four products. In simulation, a geofence that wrongly rejects at most 5% of honest students' needs a radius of 14 m when the median location error is 5 m, but 64 m when it is 30 m; in the latter case 85% of absent students standing 30 m from the room are accepted. Conclusions. A location check is a coarse filter, not proof of presence. It must be combined with a short-lived QR token, device checks, a teacher review queue for borderline scans, and data minimization. We are giving an implementation plan for LMS and HEMIS integration.

Keywords: *attendance, dynamic QR code, geofencing, LMS, HEMIS, Moodle, academic integrity, location privacy, Uzbekistan.*

1. Introduction

Attendance feeds directly into grades, scholarship eligibility and, as our earlier work argued, into early-warning models for student dropout. Yet in many classrooms it is still recorded by hand: the teacher reads names, a student answers for a friend, and the journal is typed into the system later.

A QR code shown on the board removes the manual step. The idea examined here has three rules: students scan the code with their phones and are marked present in the LMS; the scan is accepted only if the phone is inside the classroom, calculated automatically; and the teacher can change the size of the allowed area and the time during which scans are accepted, for example by closing the lesson to late arrivals after 15 minutes.

The idea is not new in principle. The HEMIS update of 12 March 2026 introduced automatic attendance with a dynamic QR code (Ta'lim xabarlari), and the Moodle Attendance plugin supports QR self-recording (Moodle docs).

What is missing from the public record is a documented combination of a rotating code, a location check, and teacher-set area and time limits, together with an honest measurement of how well the location check works indoors. This article addresses three questions:

1. **RQ1.** What do existing products and prototypes offer, and what is left uncovered?
2. **RQ2.** How reliably can a smartphone-based geofence separate students in the room from students outside it?
3. **RQ3.** What design and integration path suits an LMS and HEMIS, under Uzbek data-protection rules?

2. Methods

2.1 Market and literature scan (RQ1)

Between 10 and 16 November 2026 we read the public documentation of seven solutions: the HEMIS QR attendance announcement, the Moodle Attendance plugin, Qwickly Attendance (used in Canvas and Blackboard), Top Hat, two peer-reviewed research prototypes, and the design proposed here.

Each was scored on six controls: (1) dynamic QR code, (2) location check (geofence), (3) teacher-set radius, (4) teacher-set scan window, (5) device binding or attestation, and (6) native integration in an LMS or HEMIS.

A control scores 1 if the sources state it, 0.5 if they state it only in general terms, and 0 if not documented. The scan is a documentation review. We did not install or test the products, so "not documented" means we found no statement, not that the feature is absent.

2.2 Proposed design

The design in Figure 1 keeps every decision on the server. The teacher opens a session in the LMS and sets three parameters: geofence radius, scan window (when "Present" turns into "Late" and when scans close), and QR lifetime.

The server issues a signed token containing a session ID, an expiry time and a random nonce, and the board displays a new QR code each time the token changes (we use 20 s, the interval tested in a published prototype).

The student's app sends the token, the phone's location with its accuracy estimate, and a device-integrity proof.

The server accepts a scan only if all checks pass; borderline cases go to a teacher review list instead of being silently rejected.

For the location rule we adopt the accuracy-adjusted test $d + \lambda a \leq R$ proposed in recent work, where d is the distance from the room center, a is the reported accuracy, R is the radius and λ between 0 (lenient) and 1 (strict) sets caution (Amoanu et al., 2026).

On Android, device integrity can be checked with the Play Integrity API, whose verdicts cover app integrity, device integrity and risky apps, but which must be combined with other measures and interpreted on the server (Android Developers).

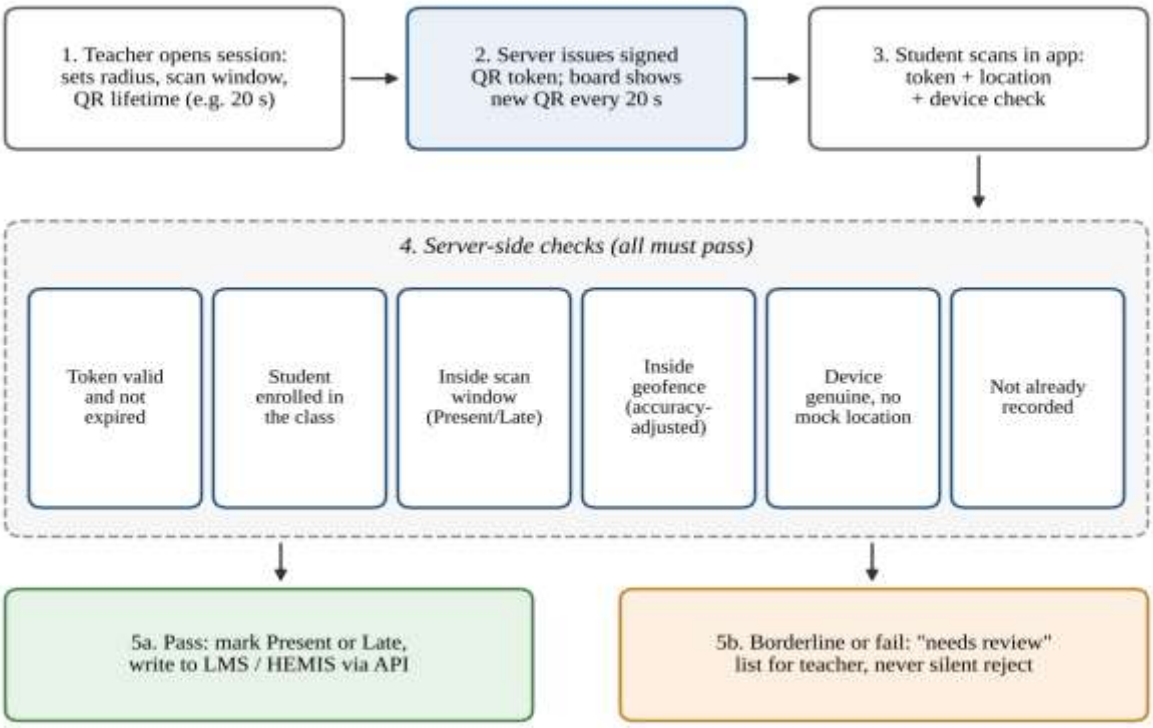

Figure 1. Proposed attendance flow: all decisions are made on the server.

2.3 Geofence simulation (RQ2)

We simulated a classroom as a disc of 8 m radius (about 200 m²). Honest students are placed uniformly inside it; the phone reports their position plus a random error drawn from an isotropic two-dimensional normal distribution. We tested four median errors taken from published smartphone measurements: 5 m (open air; Samsung S22 and S24 medians were under 5 m), 10 m (a first-floor measurement of 10.3 m), 16 m (indoor, 16.4 m) and 30 m (hotel indoor medians ranged from 28.8 to 47.9 m) (Arxiv 2603.26706). For each radius from 5 to 100 m we computed the false-reject rate (FRR: honest students rejected) and the false-accept rate (FAR: absent students accepted) for a student standing 30 m from the room centre, such as in a corridor or an adjacent building, and for one 100 m away. Each condition used 200,000 random draws (seed 2026). The simulation is synthetic: real satellite and Wi-Fi errors are not exactly normal and are correlated over time.

3. Results

3.1 What existing solutions offer

No solution reviewed documents all six controls (Table 1, Figure 2). The best-scoring item is a research prototype with 5.0 of 6; the four products score 1.0 to 2.0. The products are strongest on integration, since they live inside the LMS, and weakest on location checks, scanning windows and device binding. The HEMIS announcement confirms a dynamic QR code but is silent on location, time limits and who scans.

Table 1. Documented controls by solution (Yes = stated; Partial = stated only in general terms; N/D = not documented).

Solution	Dynamic QR	Geofence	Teacher-set radius	Teacher-set window	Device binding	Native in LMS/HEMIS	Score (of 6)

Solution	Dynamic QR	Geofence	Teacher-set radius	Teacher-set window	Device binding	Native in LMS/HEMIS	Score (of 6)
HEMIS QR attendance, Mar 2026	Yes	N/D	N/D	N/D	N/D	Yes	2.0
Moodle Attendance plugin	Partial	N/D	N/D	N/D	N/D	Yes	1.5
Qwickly Attendance	N/D	N/D	N/D	N/D	N/D	Yes	1.0
Top Hat	N/D	Partial	Partial	N/D	N/D	N/D	1.0
Prototype, Nwabuwe et al., 2023	Yes	Yes	Yes	Yes	Yes	No	5.0
Prototype, Amoanu et al., 2026	Yes	Yes	Partial	Yes	No	No	3.5
Proposed design	Yes	Yes	Yes	Yes	Yes	Yes	6.0

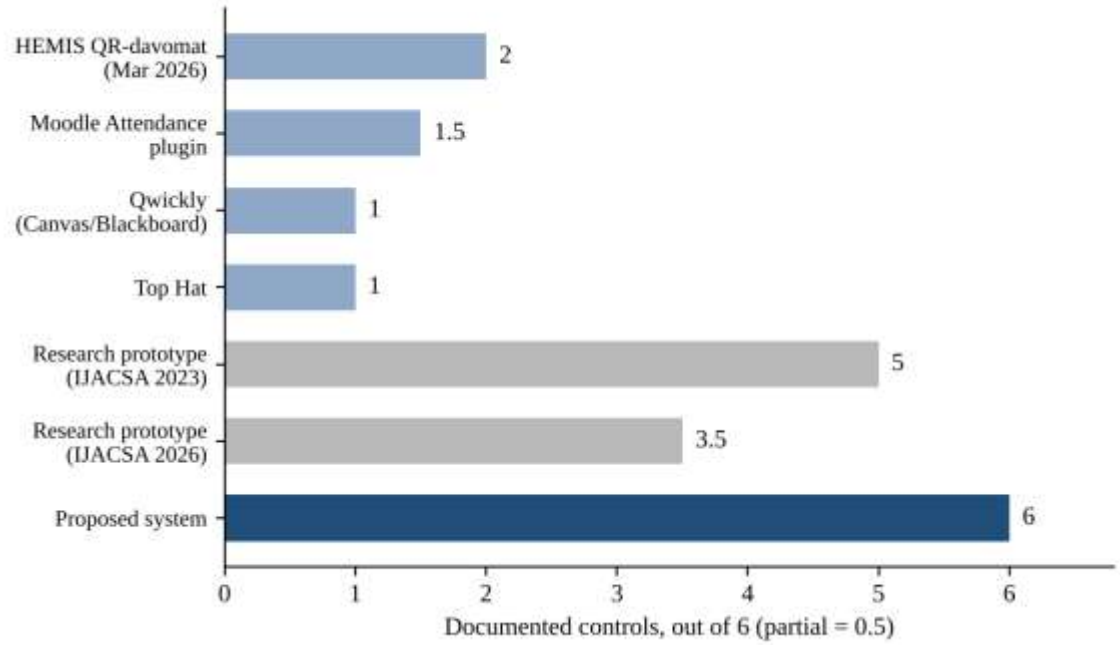

Figure 2. Documented controls out of six, by solution.

Three details qualify the table. The Moodle plugin documents a per-session password that a QR code pre-fills, and its bulk-import fields mention QR rotation, network and shared-IP options, but its documentation page does not describe rotation, location or a close-after-N-minutes rule; the plugin is installed on 22,150 sites. Qwickly offers student code check-in and QR scanning in a mobile app inside Canvas, and its page consulted does not mention location.

Top Hat describes a hybrid of polling, geolocation and proximity in a 2017 article last modified in 2023, so that row reflects the method in general, not necessarily the current product.

3.2 Geofence accuracy

Location error, not the radius setting, dominates the outcome (Figures 3 and 4, Table 2).

When the median error is 5 m, a 14 m radius keeps honest rejections under 5% and accepts no one standing 30 m away.

When the median error is 10 m the required radius grows to 23 m and 16.2% of students 30 m away are accepted. At 16 m error the radius must be 35 m, which is wider than the 30 m distance, so 56.0% of absent students nearby are accepted. At 30 m error, a 64 m radius is needed and 85.0% of students 30 m away, and 5.8% of those 100 m away, are accepted.

Table 2. Smallest radius with at most 5% of honest students rejected, and the resulting acceptance of absent students.

Median location error	Radius needed (FRR ≤ 5%)	Honest rejected	Absent at 30 m accepted	Absent at 100 m accepted
5 m	14 m	4.8%	0.0%	0.0%
10 m	23 m	4.9%	16.2%	0.0%
16 m	35 m	4.7%	56.0%	0.0%
30 m	64 m	4.7%	85.0%	5.8%

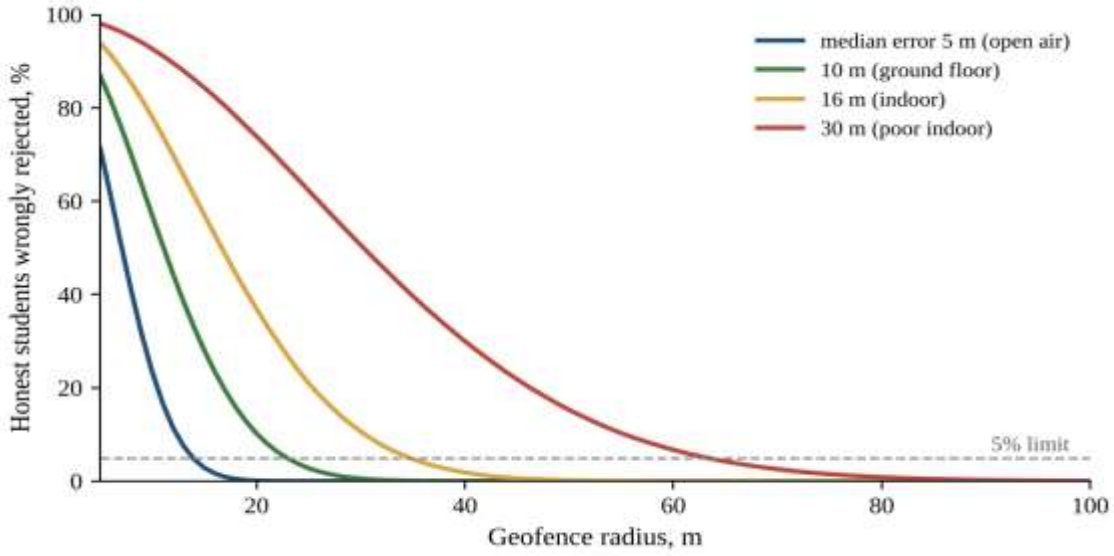

Figure 3. Simulated share of honest students rejected, by geofence radius and location error.

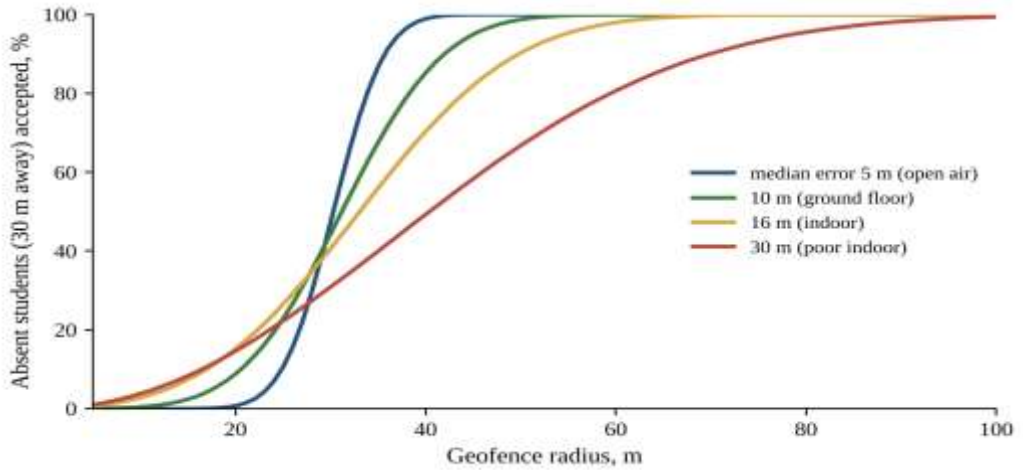

Figure 4. Simulated share of absent students 30 m from the room who are accepted, by radius and location error.

With a fixed 30 m radius, honest rejections are 0.0%, 0.5%, 10.6% and 50.6% for median errors of 5, 10, 16 and 30 m. A strict radius therefore punishes students in buildings where the signal is poor, which is exactly where classrooms are.

3.3 Threat analysis

Table 3 maps the main cheating routes to the controls of the design and to the risk that remains. The remaining risks come from the literature as well as from our simulation: a recent prototype accepted a compound attack in which a valid forwarded token was combined with fabricated coordinates inside the geofence (Amoanu et al., 2026).

Table 3. Threats, controls and residual risk.

Threat	Control in the proposed design	Residual risk
Photo or screenshot of the QR sent to a classmate	Token expires in about 20 s; a 20 s refresh blocked a shared code in a 2023 test	A friend inside the lesson can still forward within seconds
Scanning from home	Geofence plus accuracy-adjusted rule	Low if location is genuine; see next row
Fake GPS app	Device-integrity check, mock-location signals, server-side plausibility checks	Rooted or modified phones; compound attack with forwarded token
Student in corridor or next room	Geofence	High at indoor errors above 10 m (Table 2); needs Wi-Fi or Bluetooth beacon check
Friend scans with another student's phone	Device binding, one device per account	Account sharing; needs teacher spot checks
Arriving late	Teacher-set window marks Late, then closes	None if the teacher sets it
Honest student rejected by poor GPS	Teacher review list for borderline scans	Teacher workload; small if the radius is calibrated

4. Discussion

The idea is feasible, but its novelty is narrower than it first appears. HEMIS already offers a dynamic QR attendance feature, so a new product must compete on what the public record does not show: teacher-set radius and scan windows, a documented location rule, device checks and a review queue for disputed scans. The most defensible position is an extension or companion to HEMIS and Moodle rather than a rival system.

A geofence is a coarse filter. The simulation shows why. Indoors, smartphone location error is often 10 m or more, and measured medians reach 29 to 48 m in some buildings (Arxiv 2603.26706). A radius that does not wrongly reject many honest students then also admits many students who are only a corridor away. For the claim that "students who are not present cannot scan", the geofence alone cannot deliver it. It reliably stops scans from home or from another part of the city; it cannot reliably stop scans from the next room. The rotating token, the device checks and, where budget allows, a Wi-Fi or Bluetooth beacon in the room carry the remaining load.

Teacher controls need safe defaults. Letting teachers set the radius and scan window is useful, because lecture halls and lessons differ, but a radius set too tight causes false absences and one set too wide defeats the check. We suggest a default of 25 to 40 m, a "needs review" list for scans just outside it, and a scan window with two thresholds, for example Present up to 15 minutes and Late up to a closing time, as in the teacher's example. The two thresholds are choices for the pilot to test, not results of this study.

Privacy and law. A location is personal data. Summaries of the Uzbek regime state that citizens' personal data must be stored on servers in Uzbekistan, that explicit consent is central, and that databases must be registered (Legal 500). The law was amended in March 2026 (Kun.uz); a lawyer should confirm the current rules for education data. Design consequences: read the location only at the moment of scanning, keep only the verdict and the distance band (not a track), delete raw coordinates after the lesson, state this in the consent text, and host the service in-country. Students without a smartphone or with a failed scan need a manual alternative, so the teacher can always override.

Integration with LMS and HEMIS. For Moodle-based platforms the practical route is to extend the open-source Attendance plugin, which already stores sessions and statuses and has 22,150 installations. For HEMIS, the page we consulted (dgov.uz) lists attendance and electronic journals as features but mentions no public API. A package named hemisapi exists on Packagist, which suggests an interface, but we did not open or verify it. Integration therefore depends on an agreement with the HEMIS operator, and the first pilot should run in a Moodle-style LMS or as a standalone service that exports attendance.

Limitations. The market scan is a documentation review, not hands-on testing, and a product may offer features that its public pages do not mention. The simulation is synthetic, uses a normal error model and a single room geometry, and has not been validated with real phones; the error medians come from studies in other countries and buildings. The six-control score treats all controls as equally important and is a summary device, not a quality rating. A real pilot with logged scans and teacher-confirmed ground truth is the necessary next step.

5. Conclusion and implementation plan

A teacher-controlled QR and location attendance layer is technically sound and fills a documented gap, but it should be built as a layered check, not as a single location test. In our simulation a radius that keeps honest rejections under 5% was 14 m at 5 m median error and 64 m at 30 m, so the location rule alone cannot separate students in the room from students 30 m away indoors.

How to build it, in four steps:

1. **Server and rules (months 0-2).** A small web service (for example Python with FastAPI or Node.js, and PostgreSQL) that stores sessions, issues HMAC-signed QR tokens that expire in about 20 s, and applies the checks in Figure 1. Hosting in Uzbekistan from the start.
2. **Teacher and student apps (months 1-3).** First a mobile web page that opens the camera and asks for location, so students install nothing; the teacher page shows the rotating QR on the board and the settings for radius, scan window and QR lifetime. Add a review list for borderline scans and a manual override.
3. **LMS connection (months 2-4).** A Moodle plugin or an extension of mod_attendance that writes Present, Late or Absent into the course journal. For HEMIS, request API access from the operator, or export attendance as a file during the pilot.

4. **Hardening (months 4-8).** A native Android and iOS app with device-integrity checks, one-device-per-account binding, and an optional Bluetooth or Wi-Fi beacon per classroom. Then a one-faculty pilot comparing false rejections, teacher time and absence rates with the manual method. Success should be judged on three measured outcomes: share of honest students wrongly rejected, share of cheating attempts caught in staged tests, and teacher minutes saved per lesson.

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All web pages were read between 10 and 16 November 2026.

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