

MUHANDISLIK

& IQTISODIYOT

ijtimoiy-iqtisodiy, innovatsion texnik,
fan va ta'limga oid ilmiy-amaliy jurnal

2026-YIL

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- 05.01.00 – Axborot texnologiyalari, boshqaruv va kompyuter grafikasi
- 05.01.01 – Muhandislik geometriyasi va kompyuter grafikasi. Audio va video texnologiyalari
- 05.01.02 – Tizimli tahlil, boshqaruv va axborotni qayta ishlash
- 05.01.03 – Informatikaning nazariy asoslari
- 05.01.04 – Hisoblash mashinalari, majmualari va kompyuter tarmoqlarining matematik va dasturiy ta'minoti
- 05.01.05 – Axborotlarni himoyalash usullari va tizimlari. Axborot xavfsizligi
- 05.01.06 – Hisoblash texnikasi va boshqaruv tizimlarining elementlari va qurilmalari
- 05.01.07 – Matematik modellash
- 05.01.11 – Raqamli texnologiyalar va sun'iy intellekt
- 05.02.00 – Mashinasozlik va mashinashunoslik
- 05.02.08 – Yer usti majmualari va uchish apparatlari
- 05.03.02 – Metrologiya va metrologiya ta'minoti
- 05.04.01 – Telekommunikatsiya va kompyuter tizimlari, telekommunikatsiya tarmoqlari va qurilmalari. Axborotlarni taqsimlash
- 05.05.03 – Yorug'lik texnikasi. Maxsus yoritish texnologiyasi
- 05.05.05 – Issiqlik texnikasining nazariy asoslari
- 05.05.06 – Qayta tiklanadigan energiya turlari asosidagi energiya qurilmalari
- 05.06.01 – To'qimachilik va yengil sanoat ishlab chiqarishlari materialshunosligi
- 05.08.03 – Temir yo'l transportini ishlatish
- 05.08.06 – "G'ildirakli va gusenisali mashinalar va ularni ishlatish" (texnika fanlari)
- 05.09.01 – Qurilish konstruksiyalari, bino va inshootlar
- 05.09.04 – Suv ta'minoti. Kanalizatsiya. Suv havzalarini muhofazalovchi qurilish tizimlari
- 10.00.06 – Qiyosiy adabiyotshunoslik, chog'ishtirma tilshunoslik va tarjimashunoslik
- 10.00.04 – Yevropa, Amerika va Avstraliya xalqlari tili va adabiyoti
- 08.00.01 – Iqtisodiyot nazariyasi
- 08.00.02 – Makroiqtisodiyot
- 08.00.03 – Sanoat iqtisodiyoti
- 08.00.04 – Qishloq xo'jaligi iqtisodiyoti
- 08.00.05 – Xizmat ko'rsatish tarmoqlari iqtisodiyoti
- 08.00.06 – Ekonometrika va statistika
- 08.00.07 – Moliya, pul muomalasi va kredit
- 08.00.08 – Buxgalteriya hisobi, iqtisodiy tahlil va audit
- 08.00.09 – Jahon iqtisodiyoti
- 08.00.10 – Demografiya. Mehnat iqtisodiyoti
- 08.00.11 – Marketing
- 08.00.12 – Mintaqaviy iqtisodiyot
- 08.00.13 – Menejment
- 08.00.14 – Iqtisodiyotda axborot tizimlari va texnologiyalari
- 08.00.15 – Tadbirkorlik va kichik biznes iqtisodiyoti
- 08.00.16 – Raqamli iqtisodiyot va xalqaro raqamli integratsiya
- 08.00.17 – Turizm va mehmonxona faoliyati

Ma'lumot uchun, OAK
Rayosatining 2024-yil 28-avgustdagi 360/5-son qarori bilan "Dissertatsiyalar asosiy ilmiy natijalarini chop etishga tavsiya etilgan milliy ilmiy nashrlar ro'yxati"ga texnika va iqtisodiyot fanlari bo'yicha "Muhandislik va iqtisodiyot" jurnali ro'yxatga kiritilgan.

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Ibrojimova Nodira



LEARNING TRAJECTORIES OF INCLUSIVE LEARNERS IN AN INTENSIVE PEER-TO-PEER LEARNING ENVIRONMENT: POOL-TO-MAIN-TRACK TRANSITION AND PERSISTENCE

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Abstract. This article examines the learning trajectories of inclusive learners in an intensive digital learning environment based on peer-to-peer interaction, project-based progression, and the absence of traditional instructors. The study covers the period from November 2024 to May 2026 and includes 24 learners identified by the campus as belonging to the inclusive group, together with non-inclusive peers from the same pool and main-track cohorts. The quantitative phase of a sequential explanatory mixed-methods design integrates administrative pool snapshots, main-track rosters, and platform profile data. Pool-to-main-track transition rates were compared using Fisher's exact test; proportions were reported with Wilson 95% confidence intervals; and within-group platform indicators for inclusive learners were examined using the Mann–Whitney U test. The aggregate transition rate was 54.5% for inclusive learners and 74.7% for non-inclusive peers, representing a statistically significant difference ($p = 0.046$). Main-track deactivation rates did not differ significantly between the groups (23.1% vs. 16.5%; $p = 0.46$). The findings indicate that meaningful inclusion in intensive peer-driven education requires not only open access but also accessible peer-review channels, inclusive group interaction, and flexible learning design.

Keywords: *inclusive education, peer-to-peer learning, coding bootcamp, learning trajectories, main track, Fisher's exact test, Universal Design for Learning, persistence.*

Annotatsiya. Mazkur maqolada Toshkent shahridagi intensiv, an'anaviy o'qituvchisiz va peer-to-peer tamoyiliga asoslangan raqamli ta'lim muhitida inklyuziv tinglovchilarning o'quv trayektoriyalari tahlil qilindi. Tadqiqot 2024-yil noyabrdan 2026-yil maygacha bo'lgan davrni qamrab olib, kampus tomonidan inklyuziv guruh vakillari sifatida qayd etilgan 24 nafar tinglovchi hamda ayni pool va main-track kohortlaridagi inklyuziv bo'lmagan tengdoshlar ma'lumotlariga tayandi. Ketma-ket izohlovchi aralash metod dizaynining miqdoriy bosqichida pool snapshotlari, main-track ro'yxatlari va platforma profilari ma'lumotlari birlashtirildi. Pooldan main trackka o'tish ko'rsatkichlari Fisherning aniq testi yordamida taqqoslandi, ulushlar uchun Wilsonning 95% ishonch oralig'i hisoblandi, inklyuziv guruh ichidagi platforma ko'rsatkichlari esa Mann–Whitney U testi orqali baholandi. Inklyuziv tinglovchilarning umumiy o'tish ko'rsatkichi 54,5%, inklyuziv bo'lmagan tengdoshlarida esa 74,7% bo'lib, farq statistik jihatdan ahamiyatli ekanligi aniqlandi ($p = 0,046$). Main trackdagi deaktivatsiya ko'rsatkichlari o'rtasidagi farq esa statistik jihatdan ahamiyatli emas edi (23,1% va 16,5%; $p = 0,46$). Natijalar inklyuzivlikni nafaqat ochiq kirish, balki qulay peer-review kanallari, inklyuziv guruhli hamkorlik va moslashuvchan ta'lim dizayni orqali ta'minlash zarurligini ko'rsatadi.

Kalit so'zlar: *inklyuziv ta'lim, peer-to-peer ta'lim, coding bootcamp, o'quv trayektoriyasi, main track, Fisherning aniq testi, Universal Design for Learning, ta'limdagi barqarorlik.*

АННОТАЦИЯ. В статье анализируются образовательные траектории инклюзивных обучающихся в интенсивной цифровой образовательной среде, основанной на принципах peer-to-peer взаимодействия, проектного обучения и отсутствии традиционного преподавателя. Исследование охватывает период с ноября 2024 года по май 2026 года и включает 24 обучающихся, идентифицированных кампусом как участники инклюзивной группы, а также их неинклюзивных сверстников из тех же pool- и main-track-коhort. На количественном этапе последовательного объяснительного смешанного дизайна были объединены административные снимки pool, списки main track и данные профилей платформы. Для сравнения показателей перехода из pool в main track применялся точный критерий Фишера, для долей рассчитывались 95%-ные доверительные интервалы Уилсона, а внутригрупповые показатели анализировались с помощью критерия Манна–Уитни U. Совокупная доля перехода составила 54,5% среди инклюзивных обучающихся и 74,7% среди неинклюзивных сверстников, при этом различие было статистически значимым ($p = 0,046$). Различие в показателях деактивации на main track статистически значимым не являлось (23,1% против 16,5%; $p = 0,46$). Полученные результаты показывают, что полноценная инклюзия



в интенсивной peer-to-peer образовательной среде требует обеспечения доступности не только на этапе поступления, но и в процессах peer-review, группового взаимодействия и гибкого проектирования обучения.

Ключевые слова: инклюзивное образование, peer-to-peer обучение, coding bootcamp, образовательная траектория, main track, точный критерий Фишера, Universal Design for Learning, устойчивость обучения.

INTRODUCTION

Digital transformation and the expansion of technology-oriented education have increased interest in intensive, practice-based learning models that rely on project work and peer interaction rather than conventional lecture-centered instruction. Research on cooperative learning provides a theoretical basis for such models: positive interdependence, individual accountability, promotive interaction, social skills, and group processing can support learning when collaboration is deliberately structured [6]. Evidence from computing education similarly shows that peer collaboration, including pair programming, is influenced by learner compatibility and the quality of interaction [8].

However, removing formal barriers to entry does not automatically ensure meaningful inclusion. For learners with hearing, speech, motor, or visual disabilities, real-time peer communication, randomly formed groups, time pressure, and continuous peer review may create specific participation barriers. Universal Design for Learning (UDL) addresses learner variability by providing multiple means of engagement, representation, and action and expression [3; 7].

The object of the study is the learning trajectories of inclusive and non-inclusive learners within an intensive peer-to-peer education system at the Tashkent campus. The subject of the study is the group-level differences in pool-to-main-track transition, persistence in the main track, and observable platform engagement indicators. The aim of the study is to statistically assess critical transition points in the educational trajectories of inclusive learners using administrative and platform data, identify the stages at which disparities are most pronounced, and formulate evidence-based recommendations for learning design.

The scientific novelty of the study lies in examining inclusion in an intensive, tutor-less, peer-driven learning model as a sequence of educational states rather than as a single final outcome. The analysis distinguishes among pool participation, pool-to-main-track transition, and subsequent persistence in the main track. In addition, person-level platform indicators for the inclusive cohort are integrated with administrative cohort data and analyzed using statistical procedures appropriate for small samples.

LITERATURE REVIEW

The theoretical foundation of peer-to-peer pedagogy is closely related to cooperative learning and social interdependence theory. Johnson, Johnson, and Smith identify positive interdependence, individual accountability, promotive interaction, social skills, and group processing as key mechanisms through which cooperative learning can improve educational outcomes [6]. In computing education, peer collaboration has frequently been examined through pair programming. Salleh, Mendes, and Grundy synthesized 74 empirical studies and identified compatibility factors, including skill level, as important determinants of pair-programming effectiveness [8].

Intensive peer-driven environments differ from conventional pair-programming settings in several important respects. Partners are not necessarily selected or mediated by instructors, peer review may depend on learner-provided time slots, and group projects may be assigned by the platform. Consequently, peer interaction that is theoretically beneficial may also create communicative or organizational barriers under certain conditions. Hattie identifies peer tutoring as an educational approach associated with a meaningful effect on learning [5]. However, findings derived from instructor-supported contexts should be applied cautiously to tutor-less environments that also include learners with disabilities.

The Universal Design for Learning (UDL) framework proposes that educational resources and activities should be designed around learner variability rather than an assumed average learner. CAST emphasizes multiple means of engagement, representation, and action and expression [3]. Meyer, Rose, and Gordon similarly argue that flexibility should be embedded in the learning environment from the outset [7]. Applied to peer-to-peer education, accessibility therefore extends beyond the technical accessibility of the platform interface. Peer-review interactions, group projects, task instructions, and channels for demonstrating learning outcomes should also be designed to accommodate learner variability.

Longitudinal empirical evidence on learners with disabilities or other inclusive learner groups in intensive coding bootcamps remains limited. The present study therefore contributes by comparing inclusive and non-inclusive learners within the same campus and time period across the pool and main-track stages and by



linking administrative outcomes with platform telemetry available for the inclusive cohort. This approach shifts the analytical focus from whether access is formally available to whether learners successfully progress to the next stage and remain engaged after the transition.

RESEARCH METHODOLOGY

The study adopts a sequential explanatory mixed-methods design [4]. This article reports the completed quantitative phase of the thesis; the qualitative phase is designed to explain, through subsequent semi-structured interviews, the mechanisms underlying the patterns identified quantitatively. In the broader thesis, interview material is analysed through reflexive thematic analysis, following Braun and Clarke's approach to reflexive and quality-focused thematic analysis [1; 2]. The quantitative analysis reconstructs learning trajectories from secondary administrative and platform data collected by the Tashkent campus, while artificial intelligence tools were used as an auxiliary aid in preparing and editing up to 10% of the manuscript.

The inclusive cohort consists of 24 learners identified in the campus roster. Seventeen were recorded as Deaf or hard of hearing, while seven were grouped under other disabilities, including stuttering, cerebral palsy, musculoskeletal disorder, and visual impairment; several records did not specify a condition. One learner attempted the pool twice using two platform accounts. The unit of analysis for aggregate learner-level outcomes is the person, while repeated attempts are treated separately only in pool-participation analyses.

Five sources underpin the broader thesis dataset: the inclusive learner roster; 14 pool snapshots spanning November 2024 to May 2026; six main-track cohort rosters exported on 16 May 2026; platform profile exports for all 24 inclusive learners; and project-map files describing the curriculum structure. For the primary non-inclusive comparison, the denominator is conditioned on the presence of a recorded platform login because login coverage in older pool snapshots is incomplete. This convention more closely matches the known platform-engagement status of the inclusive cohort.

Pool-to-main-track transition was analysed using 2×2 contingency tables and Fisher's exact test because several inclusive cells were small. Proportions were accompanied by Wilson 95% confidence intervals. Main-track deactivation was analysed using the same Fisher procedure. Within the inclusive cohort, cumulative XP and project-related indicators were compared with the Mann–Whitney U test; rank-biserial correlation was used as an effect-size measure. Statistical significance was interpreted at $p < 0.05$, while effect estimates and data limitations were considered alongside p-values.

The construct “inclusive learner” reflects the campus roster and therefore does not necessarily capture invisible disabilities or neurodivergent conditions. “Transition” is operationalized as subsequent appearance in a main-track cohort roster. “Deactivation” is the platform status at the snapshot date and does not distinguish voluntary departure from academic or administrative exit. These operational definitions are important for interpreting the findings without making unsupported causal claims.

ANALYSIS AND RESULTS

Inclusive learners participated in seven of the thirteen pools observed during the study period. Table 1 presents pool-level transition outcomes using the login-conditioned denominator for non-inclusive learners. Two inclusive learners in pool 100000151 were still participating in the intensive phase at the snapshot date and were therefore excluded from the completed binary transition analysis (yes/no).

Table 1.
Pool-to-Main-Track Transition by Pool (Inclusive vs. Non-Inclusive, Login-Conditioned)

Pool ID	Date	Inclusive yes/ no	Inclusive %	Non-inclusive yes/no	Non- inclusive %	Fisher p
100000104	Nov. 2024	2/0	100.0	127/40	76.0	1.000
100000141	Mar. 2025	4/1	80.0	120/49	71.0	1.000
100000144	Jun. 2025	1/4	20.0	174/102	63.0	0.069
100000145	Jul. 2025	5/1	83.3	135/67	66.8	0.666
100000147	Sep. 2025	0/1	0.0	220/47	82.4	0.179
100000149	Nov. 2025	0/3	0.0	169/32	84.1	0.005
100000151	Jan. 2026	—	—	134/29	82.2	—

Source: Author's calculations based on Tashkent campus pool snapshots, inclusive learner roster, and main-track cohort records (November 2024–May 2026).

At the aggregate person level, the transition rate for inclusive learners was $12/22 = 54.5\%$ (Wilson 95% CI: 34.7–73.1%), compared with $1,079/1,445 = 74.7\%$ (Wilson 95% CI: 72.4–76.8%) among non-inclusive learners. Fisher's exact test applied to the pooled 2x2 contingency table yielded $p = 0.046$. Thus, under the stated denominator convention and within the study period, the approximately 20-percentage-point difference was statistically significant.

The pool-level pattern, however, was not uniform. In pools 100000104, 100000141, and 100000145, the transition proportion among inclusive learners was not lower than that of their non-inclusive peers. The aggregate difference was concentrated primarily in pools 100000144 and 100000149. In pool 100000149, none of the three inclusive learners transitioned to the main track, whereas the transition rate among non-inclusive learners was 84.1% (Fisher's exact $p = 0.005$). This pattern does not support a general conclusion that inclusive status inevitably leads to poorer outcomes. Rather, it suggests that participation barriers may become more pronounced under specific intake conditions. Administrative data alone, however, cannot identify the organizational, communicative, or group-interaction mechanisms underlying these differences.

Thirteen inclusive learners appeared in the main-track cohort rosters dated 16 May 2026. Of these, three were recorded as deactivated and ten as active. Among learners in the same cohorts, the deactivation rate was 23.1% for inclusive learners and 16.5% for non-inclusive learners. The aggregate Fisher's exact test yielded $p = 0.46$, indicating no statistically significant difference between the groups. This finding suggests that transition into the main track and persistence after transition should be treated as analytically distinct stages.

Table 2.
Main-Track Deactivation Status by Cohort (16 May 2026)

Cohort	Inclusive deact./active	Inclusive %	Non-inclusive deact./active	Non-inclusive %	Fisher p
24 12	0/2	0.0	57/117	32.8	1.00
25 04	3/1	75.0	117/124	48.5	0.36
25 08	0/5	0.0	21/233	8.3	1.00
25 12	0/1	0.0	0/312	0.0	1.00
26 03	0/1	0.0	0/203	0.0	1.00
Total	3/10	23.1	195/989	16.5	0.46

Source: Author's calculations based on Tashkent campus main-track cohort rosters exported on 16 May 2026.

At the cohort level, cohort 25 04 warrants particular attention: three of the four inclusive learners were recorded as deactivated at the snapshot date. In contrast, all five inclusive learners in cohort 25 08 remained active. Campus notes indicate that some deactivated learners from cohort 25 04 had left after obtaining employment. Therefore, platform deactivation should not be treated as a direct measure of academic failure, and interpreting it in this way would be methodologically inappropriate.

Platform engagement within the inclusive cohort was additionally examined using cumulative XP and project outcomes. Learners who passed the pool had substantially higher cumulative XP than those who did not. The person-level analysis yielded Mann–Whitney $U = 117$, two-sided $p < 0.001$, and rank-biserial $r = -1.00$. Because XP is accumulated through project completion, this association should not be interpreted causally as evidence that higher XP leads to pool success. Rather, it reflects a strong separation in observable platform engagement between the two outcome groups.

Several limitations should be considered when interpreting the findings. First, the inclusive cohort is small ($n = 24$), with only one to six inclusive observations in several pools. Second, login coverage is incomplete in older pool snapshots; therefore, the primary non-inclusive denominator is restricted to records with a documented platform login. Third, inclusion status is based on the campus roster and may not capture invisible disabilities or neurodivergent conditions. Fourth, detailed platform profile exports are available only for the inclusive group, preventing a symmetrical group-level comparison of XP and project indicators. Fifth, the platform does not distinguish among different reasons for deactivation.

Accordingly, the findings should be interpreted within the context of the Tashkent campus and the observation period from November 2024 to May 2026.

The findings indicate that inclusion in an intensive peer-to-peer learning environment should be understood as a stage-specific process rather than as a single institutional attribute. The aggregate transition gap is concentrated in particular pools, whereas other pools demonstrate substantially stronger inclusive outcomes. This pattern is consistent with the theoretical framework of the study, which treats peer interaction as a mechanism through which programme design features are translated into learning outcomes [6]. It is



also aligned with the principles of Universal Design for Learning, which regard learner variability as a normal condition of educational design and emphasize multiple means of engagement, representation, and action and expression [3; 7].

CONCLUSION AND SUGGESTIONS

The study demonstrates that the learning trajectories of inclusive learners in an intensive peer-to-peer environment vary across stages and cohorts. The clearest quantitative difference emerged in the pool-to-main-track transition. Of the 22 inclusive learners included in the completed transition analysis, 12 progressed to the main track (54.5%; Wilson 95% CI: 34.7–73.1%), compared with 1,079 of 1,445 non-inclusive learners (74.7%; Wilson 95% CI: 72.4–76.8%). Fisher's exact test yielded $p = 0.046$. Given the small size of the inclusive cohort and the uneven pool-level pattern, this result should be interpreted as evidence of an aggregate association within the observed campus and study period rather than as evidence that inclusive status itself caused the difference in transition rates.

Among learners who entered the main track, 3 of 13 inclusive learners (23.1%) and 195 of 1,184 non-inclusive learners (16.5%) were recorded as deactivated at the snapshot date of 16 May 2026. The aggregate difference was not statistically significant (Fisher's exact $p = 0.46$). This finding does not establish equivalence between the groups. Rather, within the available data, the study did not identify a statistically significant aggregate difference in deactivation. Cohort-level variation and the fact that the platform does not distinguish between voluntary and involuntary exits require cautious interpretation.

Based on the observed patterns, several practical recommendations can be proposed:

- formalize written, text-based, and asynchronous alternatives within peer-review processes;
- define accessible roles and communication protocols for randomly assigned group projects;
- provide project instructions through clear text, visual structure, and step-by-step guidance;
- incorporate inclusion-related indicators into routine cohort monitoring across both pool and main-track stages;
- record reasons for deactivation separately, including employment, voluntary withdrawal, academic reasons, and other causes;
- ensure that comparable platform indicators are also available for non-inclusive learners in future analyses.

Overall, open admission is an important initial condition for inclusive education, but it is not sufficient on its own. In intensive peer-driven learning environments, meaningful inclusion also depends on whether communication, assessment, group collaboration, and channels for demonstrating learning outcomes can accommodate learner variability. The qualitative phase of the broader study should therefore examine which peer-to-peer mechanisms function as sources of support and which may operate as barriers from the learners' own perspectives.

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