

Research article

Impact of Transportation Linking Projects on Student Competency Development

Impacto de los Proyectos de Vinculación en Transporte en el Desarrollo de Competencias Estudiantiles

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Fecha de Recepción: 13/06/2024

Fecha de Aceptación: 03/10/2024

Fecha de Publicación: 06/02/2025

How to cite the article:

Ortega Ortega, J., García-Ramírez, Y., & Díaz Muñoz, F. (2025). Impact of Transportation Linking Projects on Student Competency Development [Impacto de los Proyectos de Vinculación en Transporte en el Desarrollo de Competencias Estudiantiles]. *European Public & Social Innovation Review*, 10, 1-15. <https://doi.org/10.31637/epsir-2025-1441>

Abstract:

Introduction: Linking projects have become integral to Higher Education in Ecuador, necessitating thorough planning, budgeting, continuous monitoring, and rigorous presentation of outcomes. This study evaluates the impact of such projects on student competency development and society, focusing on the Logistics and Transportation Engineering program at Universidad Técnica Particular de Loja (UTPL). A linking project conducted between October 2023 and February 2024 aimed to enhance public transportation in underserved areas of Loja. **Methodology:** Methodology involved ten seventh-semester students who conducted a detailed analysis of Loja's urban transportation system using advanced tools to assess demand, service schedules, and route availability. Subsequent stages included designing efficient transportation routes and presenting proposals to stakeholders. **Results:** Results indicate significant improvements in students' technical skills, project management, and communication and teamwork abilities, alongside heightened social

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responsibility and community engagement. **Discussions:** This research underscores the pivotal role of linking projects in fostering holistic student development and addressing societal needs through practical application. **Conclusions:** The study's findings highlight the transformative impact of linking projects on student learning outcomes and their ability to contribute meaningfully to societal challenges, particularly in the context of public transportation development.

Keywords: Linking Projects; Students; Holistic Approach; Education; Transportation; Project Management; Teamwork; Routes.

Resumen:

Introducción: Los proyectos de vinculación son fundamentales en la Educación Superior de Ecuador, requiriendo planificación meticulosa, asignación de presupuestos, monitoreo continuo y presentación rigurosa de resultados. Este estudio evalúa el impacto de tales proyectos en el desarrollo de competencias estudiantiles y en la sociedad, enfocándose en el programa de Ingeniería en Logística y Transporte de la Universidad Técnica Particular de Loja (UTPL). Se realizó un proyecto de vinculación entre octubre de 2023 y febrero de 2024 para mejorar el transporte público en áreas desatendidas de Loja. **Metodología:** Diez estudiantes de séptimo semestre realizaron un análisis del sistema de transporte urbano de Loja utilizando herramientas avanzadas para evaluar la demanda, horarios de servicio y disponibilidad de rutas. Las etapas incluyeron el diseño de rutas eficientes y la presentación de propuestas a las partes interesadas. **Resultados:** Se observaron mejoras en habilidades técnicas, gestión de proyectos, comunicación y trabajo en equipo, junto con un mayor compromiso social y participación comunitaria. **Discusiones:** La investigación destaca el papel crucial de los proyectos de vinculación en el desarrollo integral de los estudiantes y en la respuesta a necesidades sociales mediante la aplicación práctica. **Conclusiones:** Este estudio subraya el impacto transformador de los proyectos de vinculación en los resultados de aprendizaje de los estudiantes y en su capacidad para abordar desafíos sociales, especialmente en el desarrollo del transporte público.

Palabras clave: Proyecto de Vinculación; Estudiantes; Enfoque holístico; Educación; Transporte; Gestión de proyectos; Trabajo en equipo; Rutas.

1. Introduction

Linked projects play a crucial role in higher education institutions, as they facilitate meaningful learning experiences for students, contribute to local development, and enhance collaboration between academia and real-world clients. These projects not only help develop graduates' skills and prepare students for the workforce but also allow universities to influence the sustainable development of the community through sustainable development education initiatives (Holzbaur, 2012). By adopting interactive learning methods, such as problem-based learning and cooperative learning, students can acquire practical skills and knowledge that are essential for their academic and professional careers and ultimately contribute to a better future for society (Vardanega & Fedeli, 2019). Furthermore, collaborative project can improve competence acquisition compared to traditional methods (Alfonso et al., 2014). Overall, linking projects is a cornerstone for bridging the gap between theoretical knowledge and real-world application, fostering a holistic approach to education and development.

Linked projects can significantly enhance student participation by providing practical and relevant real-life opportunities. Incorporating research projects into the curriculum, as observed in studies on university science students (Marley et al., 2022) has been shown to

increase student engagement. Furthermore, involving students in decision-making processes within the community can further boost their engagement (Müller-Kuhn et al., 2021). Additionally, student involvement in research, development, and teaching projects at the university level (Mata-Hernández, 2017) not only enhances their professional training but also fosters a sense of responsibility and competitiveness. Students cannot do this alone; faculty, as the institutional agents closest to the student experience, play a crucial role in developing, facilitating, and sustaining high levels of engagement (Chen et al., 2008). By aligning projects with students' interests, academic subjects, and real-world applications, educators can create a more engaging and participatory learning environment.

There are many linking projects in Engineering, but very few focus on public transportation. Public transportation plays a crucial role in urban planning and development, significantly impacting residents' quality of life. It enhances access to essential services, job opportunities, and leisure activities (United Nations Economic Commission for Europe, 2016). Efficient public transit systems can reduce commute times, improve health through increased walking, and alleviate the negative effects of automobile dependency, such as traffic congestion and environmental pollution (Karabakhtsyan, 2022). Research indicates that transportation is consistently important to quality of life across different regions, connecting people to destinations that matter most (Schneider et al., 2013). Developing sustainable urban mobility and public transport networks leads to significant improvements in citizens' quality of life, making it a critical aspect of urban planning that affects various dimensions of well-being and city functionality.

Expanding public transportation in underserved areas can significantly improve accessibility, reduce inequality, and promote sustainable urban growth. Research highlights that low accessibility leads to poor living conditions, high unemployment, and social exclusion, especially in developing countries (Mittal et al., 2022). Integrating traditional transportation infrastructure with innovative solutions, such as transportation services, can enhance social equity and provide better access to public transport for disadvantaged communities (Pramanik et al., 2023). Sustainable development initiatives emphasize balancing society, the economy, and the environment, with transportation playing a key role in achieving this balance (Ivanova et al., 2023). Disparities in accessibility and affordability persist in cities like Bogotá and Barranquilla, underscoring the importance of public transportation policies to address spatial segregation and promote equal access to opportunities (Arellana et al., 2021). Overall, investing in public transportation in underserved areas can lead to more inclusive, sustainable, and equitable urban development.

In this context, it is crucial to evaluate the impact of these projects both on society and on the development of specific competencies in students. This study evaluates a linking project conducted from October 2023 to February 2024 by 10 seventh-semester students from the Logistics and Transportation Engineering program at Universidad Técnica Particular de Loja (UTPL). Focused on expanding public transportation in underserved areas of Loja, Ecuador, the project began with an analysis of the urban transportation system using advanced tools to assess demand, service schedules, and route availability. Students then proposed new transportation lines, developing skills in project management, teamwork, and community engagement through presenting their proposals to relevant stakeholders. The study underscores how such projects enhance students' technical and social competencies, contributing significantly to their comprehensive training.

This article's main contribution lies in demonstrating how linking projects, particularly focusing on expanding public transportation in underserved areas, significantly enhance students' technical skills in project management, teamwork, and community engagement. By

addressing critical local development needs, such projects integrate theoretical knowledge with practical application, preparing students for future professional roles while promoting sustainable urban growth and social equity. Overall, the study underscores the transformative impact of interactive learning methods in higher education, fostering well-rounded professionals who can contribute effectively to society's sustainable development goals.

2. Methodology

To evaluate the impact of the linkage project on the development of student competencies, various aspects and activities in which students participated during the project were considered. The study focused on assessing competencies acquired in skills such as analysis and information search, survey design and data collection, knowledge in public transport route design, project management, teamwork, communication skills, social responsibility, and community engagement.

The research is evaluative in nature. According to Bausela Herreras (2004), evaluation processes are one of the most powerful factors for improving educational quality and measuring the impact of educational strategies. A mixed-methods approach was employed, combining quantitative methods through the application of surveys, similar to the study by Dejo (2015), who measured competency acquisition through a student self-assessment system. Another quantitative aspect was measuring the acceptance of the proposal generated in the linkage project by the beneficiaries through a satisfaction survey conducted both physically and digitally. Quantitative data such as the pass rate of subjects and the average grades obtained by the students were also considered. Regarding qualitative methods, document analysis, evaluation of submitted reports, and direct observation of activities carried out by the students were employed.

The study was conducted at Universidad Técnica Particular de Loja (UTPL), Ecuador, between October 2023 and February 2024. The linkage project was developed within the sixth cycle of the Logistics and Transportation program and was integrated into the course titled Practicum 3. This course focuses primarily on the development of a linkage project to solve a specific problem related to the academic domains of the program and provide a benefit to society.

The project included monitoring and control by the entity in charge within the university, requiring the submission of reports and continuous oversight, in addition to having an established budget. Ten students from the Logistics and Transportation Engineering program participated actively in the course and project. All students enrolled in the course actively participated in this study, ensuring a representative sample.

Several instruments were employed for data collection. Two surveys conducted with Google Forms were used to measure students' perceptions of the competencies developed: one before and one after the project. These surveys included a self-assessment system where students selected their level of proficiency (basic, intermediate, or advanced) in various aspects related to the analyzed competencies. The survey dates were carefully planned: the first survey was conducted in an initial phase of the linkage project, and the second survey was carried out once the socialization phase was completed, after students had participated in all the planned activities. A total of 10 students were surveyed, representing a 100% sample of the participants.

The survey directed at the project beneficiaries was also developed using Google Forms and was conducted after the socialization activities of the project. This survey was shared with the beneficiaries once the socialization event concluded, explaining that their participation would help obtain feedback on the activities carried out. To achieve a higher number of responses,

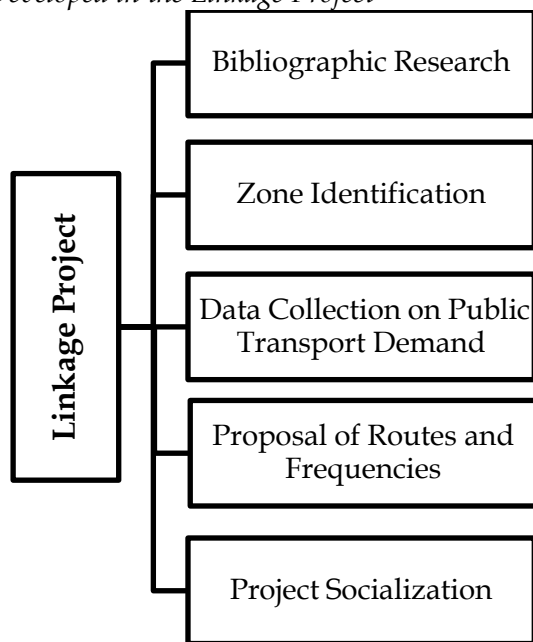
the survey was shared through WhatsApp groups of each selected study area, via the presidents of the urbanizations benefiting from the project. In total, 25 beneficiaries participated in the survey, representing a sample with an 80% confidence level and a 9% margin of error, considering that the total number of beneficiaries calculated was 2,145 people. The surveys conducted with the beneficiaries aimed to investigate their perception of the socialization activity, the information presented, the documents generated for project dissemination, the evaluation of the presented proposal, and the effectiveness of the socialization activity.

Another aspect considered was a documentary analysis, reviewing reports, documents, and submissions generated during the project, as well as direct observation of each participant. With this information, averages and statistics of the students' grades were calculated to evaluate their academic performance.

The activities carried out by the students during the linkage project, which would later be evaluated, are described below (see Figure 1) and are grouped into several phases: [1] Bibliographic Research: Exhaustive review of the literature and information collection from institutions responsible for transport in the research location (Loja, Ecuador) to gain a deep understanding of the current transport system. [2] Zone Identification: Specific selection of urban areas targeted by the project, based on information collected in the initial phase. [3] Data Collection on Public Transport Demand: Detailed analysis of the selected areas, collecting data on transport demand and the specific needs of each sector. [4] Proposal of Routes and Frequencies: Formulation of a proposal considering transport demand, routes, lines, and frequencies necessary to meet the mobility needs of the selected areas. [5] Project Socialization: Dissemination of the initiative and delivery of reports to interested parties.

Figure 1.

Activities Developed in the Linkage Project



Source: Own elaboration (2024).

The described activities ensured the proper development of the linkage project, designed for students to present a proposal that addresses a problem related to the Logistics and Transportation program. The students participated in each activity, either in groups or individually, and were assigned specific tasks such as information gathering, conducting field surveys, creating survey analysis reports, applying route optimization methodologies and calculating transportation frequencies, creating brochures, preparing final reports, and developing materials for socialization. Each of these activities was carefully evaluated by the two teachers in charge of the project. This project also had a budget of \$573.10, used for the preparation of dissemination materials, including brochures, proposal leaflets, and materials for the socialization activity.

The methodology used in the research aimed to evaluate various aspects of using linkage projects as an educational strategy. It focused on student self-assessment processes, knowledge measurement through developed activities, and the use of reports and submissions. These data were compared with student pass rates and academic success percentages to measure the impact of the linkage projects. The joint evaluation of all these aspects provides a view of the real impact of the linkage project as an educational strategy and its positive effect on the development of competencies in the involved students.

3. Results

With the methodology employed in this research, different results were obtained, considering all the aspects evaluated.

3.1. Evaluation of Competencies Acquired Through a Survey

Regarding the self-assessment survey conducted with students about the development of competencies, the results presented in Table 1 evaluated the competencies before and after the implementation of the linkage project. Aspects such as data collection, knowledge in public transport route design, project management, teamwork, communication skills, social responsibility, and community commitment were considered.

The analysis of the Table 1 reveals the evolution of various competencies before and after participating in the project. Regarding the skill in analysis methods and information search, before the project, 10% of the participants had a basic level, and 90% had an intermediate level, with no one at an advanced level. After the project, no participant remained at the basic level, 70% reached the intermediate level, and 30% reached the advanced level, showing a significant improvement in the advanced level and eliminating the basic level.

In survey design and data collection, all participants initially had an intermediate level. After the project, 70% remained at the intermediate level, and 30% advanced to the advanced level, indicating notable progress in this area. For knowledge in public transport route design, before the project, 20% were at the basic level, and 80% at the intermediate level. Subsequently, the basic level decreased to 10%, the intermediate to 70%, and the advanced increased to 20%, reflecting a general improvement in this competency.

Project management showed that before the project, 20% had a basic level, 70% intermediate, and 10% advanced. Afterward, the basic level disappeared, the intermediate level increased to 80%, and the advanced level to 20%, evidencing a clear improvement in management skills. In the competency of teamwork, initially, 60% were at the intermediate level, and 40% at the advanced level. After the project, the intermediate level dropped to 40%, and the advanced level rose to 60%, indicating a significant strengthening of teamwork capacity.

Communication skills showed no changes in the advanced level, remaining at 20%, but the intermediate level decreased from 80% to 60%, which might suggest consolidation at the intermediate level without significant advances to the advanced level. Regarding social responsibility and community commitment, initially, 70% were at the intermediate level, and 30% at the advanced level. After the project, the intermediate level dropped to 40%, and the advanced level increased to 60%, indicating notable development in this area.

Table 1.

Results of the Competency Assessment Survey

Competency	Before or After the Project	Basic Level	Intermediate Level	Advanced Level
Skill in analysis methods and information search	Before	10%	90%	0%
	After	0%	70%	30%
Survey design and data collection	Before	0%	100%	0%
	After	0%	70%	30%
Knowledge in public transport route design	Before	20%	80%	0%
	After	10%	70%	20%
Project management	Before	20%	70%	10%
	After	0%	80%	20%
Teamwork	Before	0%	60%	40%
	After	0%	40%	60%
Communication skills	Before	0%	80%	20%
	After	0%	60%	20%
Social responsibility and community commitments	Before	0%	70%	30%
	After	0%	40%	60%

Source: author (2024).

There is a considerable improvement in the advanced level of several competencies after participating in the project, suggesting a positive impact on the development of advanced skills in the participants. The reduction or elimination of the basic level in most competencies also indicates a general advancement in the participants' skills.

3.2. Evaluation of Surveys Conducted with Project Beneficiaries

The results obtained from the survey conducted with the project beneficiaries, both those who were present and those who received the information through brochures, leaflets, and WhatsApp, are indicated in Table 2. These results reflect a very positive evaluation of the socialization event and the activities presented during it. Regarding the planning and execution of the event, 40% of the respondents rated it as good and 60% as excellent, with no negative ratings. The quality and relevance of the content presented were considered adequate by 12%, good by 68%, and excellent by 20% of the participants. In terms of understanding the project, 28% indicated that the content helped them quite a bit, while 72% stated that it helped them completely, with no negative responses in this category.

Similarly, the dissemination materials used during the event, such as brochures and leaflets, were rated as good by 20% and excellent by 80% of the respondents. The proposal for public transport routes for underserved areas in Loja, Ecuador, developed during the project, received satisfactory opinions from 44% and very satisfactory opinions from 56%, with no negative opinions. Regarding the feasibility of the proposal, 8% considered it to be slightly feasible, 32% rated it as neutral, 44% saw it as feasible, and 16% as very feasible, with no responses indicating it was not feasible.

The effectiveness of the feedback session for gathering opinions and suggestions was rated as neutral by 24%, effective by 20%, and very effective by 56% of the respondents, with no responses indicating it was very ineffective or ineffective. These results suggest that the event and the proposal were well received and considered useful and effective by the participants, highlighting the high evaluation of the content and the positive perception of its relevance and applicability. The active participation of the students during this event was good, contributing to the overall success of the project and the acquisition of competencies for them.

Table 2.

Survey Results from Beneficiaries

Question	Rating	Result
How would you rate the planning and execution of the socialization event?	Very poor	0%
	Poor	0%
	Regular	0%
	Good	40%
	Excellent	60%
How would you rate the quality and relevance of the content presented during the socialization?	Very poor	0%
	Poor	0%
	Adequate	12%
	Good	68%
	Excellent	20%
Did the presented content help you better understand the project?	Not at all	0%
	A little	0%
	Somewhat	0%
	Quite a bit	28%
	Completely	72%
What impression did the dissemination materials (brochures, leaflets) used during the event make on you?	Very poor	0%
	Poor	0%
	Regular	0%
	Good	20%
	Excellent	80%
What do you think of the public transport route proposal for underserved areas in Loja?	Very unsatisfactory	0%
	Unsatisfactory	0%
	Neutral	0%
	Satisfactory	44%
	Very satisfactory	56%
Do you consider the presented proposal feasible for implementation in reality?	Not feasible	0%
	Slightly feasible	8%
	Neutral	32%
	Feasible	44%

How would you evaluate the effectiveness of the feedback session in capturing opinions and suggestions?	Very feasible	16%
	Very ineffective	0%
	Ineffective	0%
	Neutral	24%
	Effective	20%
	Very effective	56%

Source: Author (2024).

3.3. Grades Obtained and Pass Rate

Each of the activities developed during the process of the linkage project were evaluated, including both individual and group activities. These activities ranged from bibliographic information search, the development and implementation of field surveys, participation in survey analysis, information classification, planning of transportation routes and frequencies, to the preparation of materials for socialization and participation in these socialization activities.

In each of these activities, students applied various competencies, both knowledge and skills. The activities were evaluated individually and in groups, depending on the project's organization. The pass rate for the course in which this project was developed was 100%, meaning that all students obtained the minimum grade to pass the course, which is 7 out of 10.

The average grade obtained by the students in all the activities developed was 8.42, with a minimum grade of 7.81 and a maximum grade of 8.80. The grading process was rigorous and ensured that all students participated in the planned activities.

3.4 Comprehensive analysis of the results obtained

The comprehensive analysis of competency assessment data, beneficiary surveys, and student grades reveals a clear relationship between the implementation of the linkage project and the improvement in various competencies among the participants. The results presented in Table 1 show significant improvements in several competencies after participating in the project. For instance, the skill in analysis methods and information search improved notably, with 30% of participants reaching the advanced level, and no participants remaining at the basic level. This pattern of improvement is repeated in competencies such as survey design and data collection, knowledge in public transport route design, and project management. The transition from intermediate to advanced levels, along with the reduction or elimination of the basic level, indicates substantial improvement attributable to the project activities.

The evaluation of surveys conducted with project beneficiaries, reflected in Table 2, shows a very positive assessment of the socialization event and the activities presented. Regarding the planning and execution of the event, 40% of the respondents rated it as good and 60% as excellent. The quality and relevance of the content were considered adequate by 12%, good by 68%, and excellent by 20% of the participants. Additionally, 72% of the respondents stated that the content completely helped them better understand the project. These results suggest that the project's communication and dissemination efforts were highly effective.

The academic evaluation of the students shows that all of them passed the course, with an average grade of 8.42, a minimum of 7.81, and a maximum of 8.80. This 100% pass rate, along with the rigorous grading process and active participation in the planned activities,

corroborates the positive impact of the project on student performance. Overall, these data demonstrate that the linkage project was successful in improving the participants' competencies, facilitating high levels of student engagement and performance, and receiving positive feedback from the beneficiaries. This underscores the project's effectiveness in achieving its educational and social objectives.

4. Discussion

In the study conducted at Universidad Técnica Particular de Loja (UTPL), a significant improvement in various competencies was observed after the implementation of the linkage project. The results showed that competencies in analysis and information search, survey design and data collection, knowledge in public transport route design, project management, and teamwork improved significantly. For example, the skill in analysis methods and information search saw a 30% increase at the advanced level, completely eliminating the basic level. These results align with the findings of Marín-Figuera & Manjarréz-Zambrano (2022), who highlighted that university linkage projects enable students and community members to gain significant learning through interaction and practical experience. In both studies, it is emphasized that linkage not only benefits students but also the community, creating a cycle of continuous learning and improvement.

The results of the surveys with the beneficiaries of the project at UTPL indicated high satisfaction with the planning, execution, and content of the socialization event. Sixty percent of the beneficiaries rated the execution of the event as excellent and 40% as good, with no negative evaluations. Additionally, the quality and relevance of the content presented were considered adequate by 12%, good by 68%, and excellent by 20% of the participants. These results are consistent with the findings of Jurado Vite et al. (2018), who implemented a geographic visualization system to manage linkage projects and observed that proper planning and the inclusion of technology enhance the perception and impact of the projects in the community. The use of technology in the UTPL project, such as digital tools for data collection and analysis, as well as for the socialization of the results, was crucial for achieving this high rating, reinforcing the idea that technology can amplify the reach and effectiveness of linkage projects.

One hundred percent of the students who participated in the linkage project at UTPL passed the course, with an average grade of 8.42, a minimum of 7.81, and a maximum of 8.80. These results correlate with those obtained by (González et al., 2019), who found that participation in linkage projects can have a significantly positive effect on students' academic performance. The improvement in academic performance suggests that linkage projects not only enrich the learning experience but also motivate students to engage more deeply in their studies and apply their knowledge in practical and real contexts.

The proposal for transport routes for underserved areas in Loja, developed during the UTPL project, received satisfactory opinions from 44% of the beneficiaries and very satisfactory opinions from 56%. Additionally, 60% of the respondents considered the project's socialization as excellent and 40% as good. These results reflect an understanding and appreciation of the practical solutions developed. This finding is consistent with the work of Rojas Molina et al. (2023), who emphasized the importance of understanding and addressing the specific needs of the community for the success of linkage projects. Effective identification of needs and the proposal of solutions based on rigorous data and analysis proved to be crucial strategies for the success and acceptance of linkage projects by the community.

The results of this study at UTPL show significant alignment with the conclusions of previous studies on university linkage projects. The implementation of a robust methodological approach and the use of advanced technological tools have proven to be key factors for success in both the development of student competencies and the positive impact on the community. These findings reinforce the importance of linkage projects as effective educational and social strategies that benefit both students and the communities involved. The study confirms that university linkage, when properly executed, can be a powerful tool for competency development and strengthening the bond between academia and society.

5. Conclusions

The study conducted at Universidad Técnica Particular de Loja (UTPL) demonstrated a significant improvement in various student competencies following the implementation of the linkage project. The results showed that competencies such as analysis, information search, survey design, and data collection improved notably. All students participating in the project passed the course with a 100% pass rate, indicating that participation in linkage projects not only enhances students' practical skills but also positively contributes to their overall academic performance.

Surveys conducted with the project's beneficiaries indicated high satisfaction with the planning, execution, and content of the socialization event. Participants considered the quality and relevance of the content presented to be good or excellent, highlighting the effectiveness of using digital tools for data collection and dissemination. The proposal for transport routes for underserved areas in Loja was well received by the beneficiaries. This acceptance demonstrates the importance of developing solutions based on rigorous data and analysis that respond to the specific needs of the community. Effective identification of community needs and the formulation of appropriate solutions were key to the success of the linkage project. This reinforces the importance of conducting detailed analysis and careful planning when designing linkage projects.

The use of advanced technological tools for data collection, analysis, and dissemination was crucial to the project's success. The implementation of information and communication technologies (ICT) amplified the project's reach and effectiveness, improving both the perception of the beneficiaries and the academic results of the students.

Based on the results obtained, it is recommended to continue integrating linkage projects into the academic curriculum, utilizing mixed methodologies and technological tools to maximize the positive impact on both students and the community. Longitudinal studies are suggested to evaluate the long-term impact of these projects on competency development and the well-being of the beneficiary communities. The results of this study suggest that educational policies should encourage and support the implementation of university linkage projects as an integral part of study programs, providing adequate resources and training to ensure their success and sustainability.

Linkage projects contribute significantly to the training of students in the Logistics and Transportation Engineering program, equipping them with skills that cannot be developed through other academic activities. Besides benefiting students, these projects help address issues directly related to the field, such as the deficiency of public transportation in the study area. The study confirms that university linkage, when properly executed, can be a powerful tool for the development of student competencies and the strengthening of the bond between academia and society, significantly benefiting all parties involved.

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Funding: This study did not receive external funding.

Acknowledgment: Thanks to the Universidad Técnica Particular de Loja of the Republic of Ecuador for their collaboration and support.

Conflict of interest: The Authors declare that they have no conflicts of interest.

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