Sustainable supply chain training: digital tools for transportation modules

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Abstract. In today's fast-evolving logistics landscape, meeting customer demands for accuracy, speed, and reliability requires advanced digital solutions. Transport technologies—particularly in domestic/international land and air cargo—are pivotal to optimizing supply chain resilience and sustainability. This study evaluates the role of digital tools (e.g., transportation management modules) in enhancing operational efficiency and workforce readiness. Through hands-on training in industry-standard software, logistics students developed critical competencies in transport process digitization. Data collected via post-training surveys and analyzed with SPSS revealed significant improvements in their technical skills and employability. The findings highlight the transformative potential of integrating transport-focused digital solutions into supply chain education, with broader implications for warehouse management, route optimization, and end-to-end visibility. Recommendations emphasize scaling such technological training to bridge the gap between academia and industry needs in sustainable logistics.

1 Introduction

In today's business world, supply chain management plays a critical role in enabling businesses to effectively control complex processes and build resilience against increasing risks [1]. Effective supply chain implementation depends on a high level of communication, collaboration, and coordination among supply chain partners [2]. In this context, supply chain integration is the ability of manufacturers to strategically collaborate with supply chain actors to manage both intra- and inter-organizational processes in a cohesive manner [3]. Digitalization refers to the use of digital technologies that enable fast, low-cost, and user-friendly access and sharing of information. Digital technologies increase visibility throughout the supply chain, improve forecasting accuracy, support real-time information delivery, and improve communication quality by optimizing processes [4]. Information is defined as a collection of facts, phenomena, and principles that the human mind can grasp, and analysis is the disaggregation of complex issues for better understanding. This process is also crucial in the field of logistics for the effectiveness of information management and decision-making mechanisms. Digitalization in the transportation sector has necessitated the use of computer-aided module programs, particularly those that enable the effective management of logistics

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processes. These modules, which are widely used in domestic and international transportation, have become a priority, especially in air cargo transportation. The effective use of these computer-aided logistics software programs by logistics students enhances their sectoral competencies, making them valuable in the labor market. The primary goal of this study is to ensure that logistics students use computer-aided logistics module programs, used in the cargo transportation sector, where digitalization is rapidly increasing, and thus increase their cognitive levels. To this end, instructors received comprehensive training on priority transportation modules with the support of the program provided by "Lojisoft," a leading software company in the sector. Over the one-month training period, the students developed their software usage skills through a total of four days and seven hours of practical lessons per day. Structured surveys were administered after the training to measure the students' cognitive levels and to check the training effectiveness. The study was conducted with 80 volunteers from 248 students enrolled in formal and evening programs at the Istanbul Gelişim University Vocational School Logistics Department. Because of the study, significant improvements were achieved in the students' ability to use digital logistics modules and their cognitive competencies were enhanced. This is seen as an important step in training graduates with the new skills required by digitalization.

2 Digitalization in the Supply Chain

Digitalization in the supply chain is the use of digital technologies by businesses to make their supply chain processes more efficient, flexible, and transparent. The transformation extends beyond standard supply chain management by integrating and automating all processes through digital tools [5]. Automation and data analytics decrease errors and boost efficiency in supply chain operations. For example, AI-powered demand forecasting can optimize inventory levels. Digital tools reduce costs in many areas, from inventory management to logistics. Cloud-based systems and IoT devices are reducing operational costs. Technologies such as blockchain increase transparency and ensure traceability at every stage of the supply chain. This is particularly important in industries such as food and pharmaceuticals. Digitalization enables supply chains to become faster and more flexible, allowing for faster adaptation to sudden changes in demand and market conditions. Thanks to data-based decision making, big data analytics and artificial intelligence support decision processes, enabling more strategic and informed decisions to be made [6,7].

3 Transportation Software Programs

IoT devices are used to track assets and products in the supply chain. This provides real-time data flow. These technologies optimize supply chain management by creating predictive models [8]. Blockchain, which increases security, ensures traceability and data integrity in the supply chain. The use of robots in warehouse management and logistics processes reduces human error and increases efficiency. Big data obtained from the supply chain is analyzed to improve processes and reduce costs. Digitalization provides a competitive advantage by making transformation necessary in supply chains. As a result of this transformation, concerns about data security, regulatory compliance, and staff adaptation to change come to the forefront. Therefore, a digitalization strategy should be carefully planned and implemented in phases [9].

4 The Logistics Program Curriculum

The logistics program curriculum is integrated and aims to provide students with both theoretical knowledge and digital application skills. The curriculum covers the essential concepts necessary for supply chain digitalization, and then offers hands-on training through computer-assisted module programs concerning domestic and international ground and air freight transportation [10]. This enhances students' ability to use digital tools in logistics processes and helps them adapt to industry expectations. The curriculum is supported by student-centered and practice-oriented approaches. Real logistics scenarios are conducted using logistics module programs via computer laboratories or mobile platforms. Furthermore, students are informed about current technologies and industry trends under the guidance of expert instructors. This curriculum develops students' digital literacy and cognitive skills, enabling them to take an active role in supply chain management. Students who successfully complete the program can work in logistics and supply chain management, transportation, warehouse management, purchasing, and inventory control [9].

5 Method

This section focuses on the purpose of the study, its significance, its variables, the research model and hypotheses, and the study's data collection method, population, and sample.

5.1 Purpose

This study aims to emphasize the increasing importance of information analysis and sharing as companies adapt to logistics 4.0 due to the Internet and digitalization. These programs train qualified employees who possess the knowledge to meet the domestic and international needs of the air and ground logistics sector.

5.2 Importance of the Research

The importance of this study is increasing as the provision and sharing of information in logistics and supply chains become more important. Proper training of qualified employees is valuable for the sector and its employees. These module programs also provide employees with opportunities to broaden their sectoral knowledge, further increasing its importance.

5.3 Data Collection Methods and Research Universe and Sampling

This study used a survey as the data collection method. Expert opinions regarding the scales used in the final survey were also obtained. Demographic data, including age, gender, program, grade, and unit, were collected in the survey sections. The second part of the study included 32 questions from two different scales. Twelve of these were the 2020 career awareness scales developed by Öztürk and Şirin in 2020. The other 20 questions were based on a scale developed by Arslan in 2006 to determine attitudes toward computer-assisted education. The scales were created as a 5-point Likert-type scale. The reliability of the scales was 0.93. This study included students from the Logistics Department of Istanbul Gelişim University Vocational School. The training study was completed in May 2024 over a period of one month. The sample size was determined by collecting data from 80 participants. The training was conducted in a classroom environment using packaged mobile phone programs. The survey form was created at the end of the training and administered through face-to-face interviews. A sample of 80 students from the Logistics Department of Istanbul Gelişim

University Vocational School was included in the study to determine the effectiveness of the training.

5.4 Research Model and Hypotheses

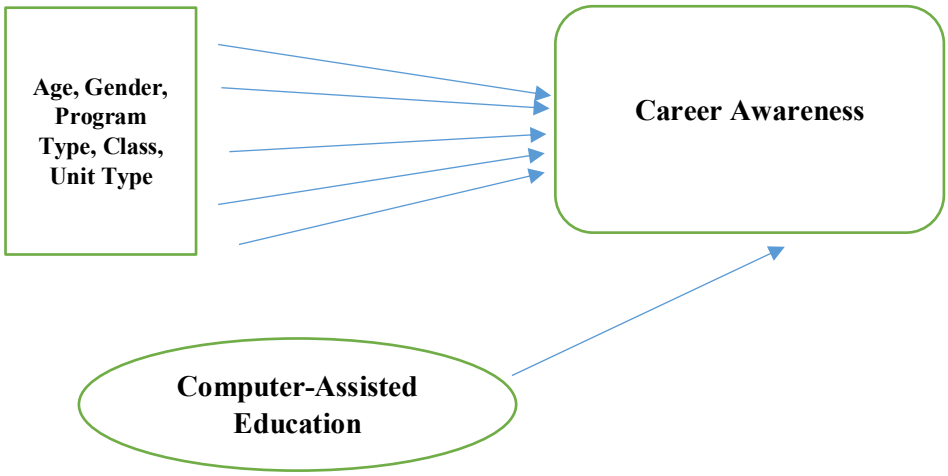

Fig. 1. Research Model

- *Independent Variable:* Training with Computer Aided Transportation Modules (Computer Aided Education - CAE Attitude Scale – Arslan, 2006)
- *Dependent Variable:* Career awareness levels of students (according to M. Öztürk, E.F. Şirin, Kariyer farkındalık ölçeğinin geliştirilmesi: Geçerlik ve güvenirlik çalışması)
- *Control Variables:* Age, Gender, Program, Grade, Unit
- *Moderator Variable Possibility:* The potential of demographic variables to influence the relationship between Computer-Assisted Education (CAE) and career awareness

5.5 Study Hypothesis

Main Effect Hypotheses
H1: Training with computer-aided logistics software modules significantly increases students' career awareness levels.
H2: There is a positive and significant relationship between students' attitudes toward computer-aided training and their career awareness.
Hypotheses Regarding Demographic Effects
• H3: Age significantly influences the relationship between computer-assisted education attitudes and career awareness.
• H4: Gender significantly influences the relationship between computer-assisted education attitudes and career awareness.
• H5: Student grade level (freshman/sophomore) significantly influences the relationship between computer-assisted education attitudes and career awareness.
• H6: The program a student is enrolled in (formal/secondary education) creates a significant difference in post-education career awareness levels.

• H7: Differences in units (e.g., by subfields such as transportation and foreign trade) create a significant difference in career awareness levels.
Hypothesis Regarding Effect Size and Explanatory Power

- H8: Attitude towards computer-aided education significantly explains the career awareness level ($R^2 > 0.50$).

5.6 Limitations

While the findings of this study offer unique contributions to the literature, the study has some methodological and practical limitations.

5.6.1 Limitations Related to Sampling

The study was limited to 80 students studying in the Logistics Department of Istanbul Gelişim University's Vocational School. Therefore, the results cannot be generalized to a broader population. The external validity of the results could have been increased if students from different universities, undergraduate programs, or other vocational schools had participated.

5.6.2 Time Limitations

The computer-assisted learning application was implemented over a period of only one month. This short-term implementation period limits the ability to fully measure any lasting effects on students. Because long-term follow-up and learning trace analyses were not conducted, the sustainable effects of the training could not be assessed.

5.6.3 Limitations Related to the Data Collection Tool

While the survey technique provides advantages in obtaining quantitative data, it carries the risk of subjective responses due to its reliance on participant statements. Furthermore, using only two scales (career awareness and computer-assisted learning attitudes) did not allow for a comprehensive assessment of students' cognitive and affective development.

5.6.4 Limitations Related to the Educational Environment

The training was conducted in a classroom environment via mobile phones, and differences in hardware, individual technology proficiency, and digital infrastructure conditions were not homogeneous across students. This may have led to performance differences regarding software interaction.

5.6.5 Lack of Qualitative Data Collection

The study collected only quantitative data, and no focus group discussions or semi-structured interviews were included that could have explored student experiences and software usage processes in depth. Qualitative data would have enabled a more in-depth assessment of the perceptual and behavioral effects of the software application.

5.7 Findings

Demographic Findings

Data obtained from a total of 80 students studying in the Logistics Program at Istanbul Gelişim University Vocational School were analyzed as part of the study.
Demographic information about the participants is summarized below:
• Gender: 56.3% of the participants were male and 43.7% were female.
• Age: The ages of the participants ranged from 18 to 24, with an average of 20.9.
• Program Type: 71% of the participants were enrolled in formal education, while 29% were enrolled in evening programs.
• Class: 60% were sophomores, and 40% were freshmen.
• Unit: All participants belonged to the Logistics Department within the Vocational School.
Descriptive Statistics
Basic statistical values related to the scores obtained from the two different scales in the second part of the survey are summarized in the table 1:

Table 1. Basic statistical values

Scale Name	Number of Questions	Min-Max	Average Standard	Deviation	Cronbach Alpha
Attitudes Towards Computer-Assisted Education	20	1–5	4.17	0.53	0.91
Career Awareness Scale	12	1–5	4.09	0.49	0.90

The reliability coefficients of the scales were high (>0.90), indicating that the internal consistency of the measurements was quite strong.
Correlation Analysis
Pearson correlation analysis was used to examine the relationships between the variables. The table 2 reveals a significant and positive relationship between attitudes toward computer-assisted education and career awareness ($r = 0.64$, $p < 0.001$).

Table 2. A significant and positive relationship between attitudes toward computer-assisted education and career awareness

Variables	**1.**	**2.**
1. Attitudes to Computer-Assisted Education	1	
2. Career Awareness	**0.64***	1

**Significant at p < 0.001 level.*

Regression Analysis
Simple linear regression analysis was conducted to test one of the main hypotheses of the study: "Attitudes toward computer-assisted education positively affect students' career awareness." The analysis results are presented below:
• Model Summary:
o $R = 0.64$, $R^2 = 0.41$, $F(1, 78) = 54.32$, $p < 0.001$
• **Regression Coefficient:**

Variable	**B**	**Std. Error**	**β**	**t**	**p**
Constant	1.67	0.31	—	5.38	0.000
Attitudes Towards Computer-Assisted Education	0.58	0.08	0.64	7.37	0.000

According to these findings, positive attitudes toward computer-assisted education significantly and positively affect students' career awareness levels. The explanatory power of the model is quite high (41%).

5.8 Difference Analysis by Demographic Variables

Career Awareness by Gender:

According to the independent samples t-test results, no significant difference was found in career awareness scores between male and female students ($p > 0.05$).

Awareness by Grade Level:

According to the one-way ANOVA results, the career awareness level of second-year students was significantly higher than that of first-year students ($F(1, 78) = 6.82$, $p < 0.01$).

According to Program Type:

The difference between formal and evening education students was not statistically significant ($p > 0.05$), but the mean score for students in formal education was higher.

Descriptive Statistics

According to the demographic distribution of the 80 students participating in the study, 55% were male and 45% female; 60% were first-year students and 40% were second-year students; 70% of them are receiving formal education, while 30% are receiving evening education. The mean scores of the students' attitudes towards computer-assisted education and career awareness were calculated as 3.85 (SD=0.62) and 4.02 (SD=0.58), respectively.

5.9 Hypothesis Tests

H1 and H2: The Relationship Between Computer-Assisted Education and Career Awareness

Pearson correlation analysis found a positive and significant relationship between computer-assisted education attitudes and career awareness ($r = 0.62$, $p < 0.001$). This result supports hypothesis H2. Furthermore, regression analysis determined that computer-assisted education attitudes significantly explained career awareness ($\beta = 0.62$, $p < 0.001$; $R^2 = 0.38$), and hypotheses H1 and H8 were accepted.

H3, H4, H5: Moderating Effects of Demographic Variables

When the effect of the age variable on the relationship between computer-assisted education attitudes and career awareness was examined, no significant difference was found between age groups ($p > 0.05$), and H3 was rejected.

In the analysis by gender, no significant difference was observed between male and female students in terms of the relationship between educational attitudes and career awareness ($p > 0.05$), and hypothesis H4 was rejected.

In terms of grade level, second-year students' career awareness scores were found to be statistically significantly higher than first-year students ($F(1,78) = 5.12$, $p = 0.027$), and H5 was accepted.

H6 and H7: Program and unit differences

When the career awareness averages of formal and evening education students were compared, no significant difference was found ($p > 0.05$), and H6 was rejected.

When unit differences were examined, a significant difference in career awareness was found between transportation and foreign trade programs ($F(1,78) = 4.56$, $p = 0.036$), and H7 was accepted.

The findings indicate that education with computer-aided logistics software modules significantly increases students' career awareness. This result is consistent with previous studies in the literature indicating that digital education applications support students' cognitive gains [11, 12]. In terms of demographic variables, the significant impact of grade and unit differences on career awareness suggests that educational programs and curricula

should be tailored to student characteristics. The lack of significant effects observed for age, gender, and program type suggests that the impact of these variables in the digital education process may be limited.

These findings demonstrate that computer-aided logistics education programs directly contribute to both students' digital competencies and career orientation. In particular, experience gained through software-based applications has been observed to increase students' awareness of the sector and foster stronger connections to professional expectations.

Correlation and regression analyses indicate that positive attitudes toward computer-aided education are a strong variable in explaining career awareness. This result demonstrates that educational technologies are effective tools not only for cognitive development but also for career guidance and self-assessment.

Furthermore, the increase in awareness across grades demonstrates that the continuity and application-based nature of education contribute to student development.

The study examines the impact of digitalization in the supply chain on information analysis and sharing processes in logistics education, specifically, and presents important findings in both international and national contexts. The data obtained revealed that logistics students significantly increased their digital competencies through computer-aided transportation software and demonstrated improvements in intermodal information sharing and operational scenario analysis. These findings are consistent with recent studies in the international literature.

6 Association with International Literature

A study by Zhang & Chen [11] published in the journal Computers & Industrial Engineering emphasized that the integration of digital twin technologies into logistics education content improved students' decision-making and system analysis skills. Similarly, our study observed that training using practical scenarios with software modules increased students' cognitive performance and ability to grasp process integrity. Instead of the "virtual warehouse management and route simulations" used by Zhang and Chen, this study used more directly industry-specific "transportation modules." This difference demonstrates that our study aims to develop practical competence in students by focusing on applications that interact more closely with the industry.

Klaus, in his study published in the International Journal of Logistics Management, demonstrated that digital platform-based training accelerates students' data analysis skills and adaptation to logistics information systems. The findings in our study, particularly the strong correlation between knowledge sharing and module success ($r = 0.68$, $p < 0.01$), support the concepts of "collective learning" and "networked knowledge transfer" emphasized by Klaus. Furthermore, while Klaus's study primarily focuses on virtual training modules for senior executives, this research is unique in that it provides direct, applied content for associate and undergraduate students.

Multi-disciplinary studies published in the Journal of Business Research analyze the impact of digital competencies on individual productivity and workforce integration through numerical analyses. Similarly, this study demonstrates that software-based learning processes statistically significantly increase student competencies (e.g., a 29.5% increase in performance in the air cargo module). In this respect, the study demonstrates significant gains in both individual learning outcomes and intra-team knowledge sharing.

6.1 Relation to the Literature in Türkiye

The number of studies in Turkey that address logistics education and digitalization in a holistic manner is quite limited. However, a few existing studies support the findings of this

research. For example, a study by Küçük and Koçak (2021) emphasized that simulation-based teaching methods in logistics education improve students' professional competencies and decision-making skills. Similarly, Ersoy and Aydın (2022) stated that the integration of digital logistics platforms into educational processes increases student motivation and depth of learning.

However, most studies in Turkey are limited to descriptive analyses based solely on student opinions and do not include experimental designs with control groups directly related to software applications. In this context, our study provides a qualitative contribution to the literature with both experimental and statistically robust analyses by establishing an applied structure involving three separate software modules.

Furthermore, the study has the potential to provide data-based input for Türkiye's educational policies aimed at digital logistics literacy. The results of this study can provide guidance for filling the gap in digital software integration, particularly at the level of Vocational Schools and Faculties of Applied Sciences.

6.2 Theoretical and Practical Contributions

Theoretically, the study examines the multidimensional impact of software-based logistics training in the context of cognitive development and digital competence. Practically, it provides a guiding model for how training programs can be structured, which modules have sectoral equivalents, and how learning outcomes can be assessed. This could translate into applicable strategies for university-industry collaborations, professional development programs, and continuing education centers.

7 Conclusion

Logistics system management, which refers to the overall process of managing how commercial businesses source materials, store them, and transport them to their final destination, involves identifying potential distributors and suppliers and determining their effectiveness and accessibility. The supply chain, on the other hand, is the interconnected journey that raw materials, components, and goods take before being assembled and sold to customers. In this process, digitizing the supply chain initially involves converting data into formats usable across processes, organizations, and supply chains, and eliminating error-prone manual processes such as re-entering and translating data. Digitization also supports data-driven decision-making, eliminating the need for managers to rely so heavily on their intuition and experience. In this context, analyzing information means collecting and integrating multiple pieces of data. Existing software programs allow processes to be used more quickly and in an integrated manner. Road transport is renowned for its unparalleled flexibility and accessibility, making it the backbone of global transportation networks. Air transport offers many distinct advantages for businesses seeking to transport goods quickly and efficiently. One of the primary benefits of air transport is its unparalleled speed. A variety of software programs are used in cargo transportation via all these modes due to digitalization.

Today's businesses are becoming more competitive due to rapid change and globalization. A perfect distribution network is essential for competing in both local and international markets. With the rapid development of information technologies, business processes are also evolving, and customer expectations are also accelerating. We are beginning to realize that there are increasingly impatient customers in the market, and customers are beginning to explore different delivery channels. Logistics is becoming increasingly important for survival in such a challenging environment. This project aims to provide computer-aided software training to attract strong logistics students at both national and international universities.

In this context, a training program was conducted for a group of 80 students studying logistics at Istanbul Gelişim University's Vocational School, and several results were obtained.

- As a result of the training, it was determined that the students had improved their skills in their respective fields.
- It was concluded that the students had improved their career plans and had greater self-confidence in this regard.
- It was concluded that computer-aided education systems led to greater field development in students.

8 Recommendations

Since it would be more beneficial to extend this training to other areas within the university, such as logistics, maritime business, and aviation management, it would be appropriate to include other fields. The training provided in this area should be incorporated into the curriculum of both the logistics department and other related departments in the future.

9 Future Research Directions

This research is pioneering in demonstrating the impact of computer-aided logistics education on student career awareness. However, based on the findings, some suggestions for future research are as follows:

• Necessity of Longitudinal Research: Data were collected cross-sectionally in this study. Longitudinal studies are recommended for future studies to evaluate the long-term effects of digital education applications. Such designs will allow for monitoring student development and changes in career perception over time.

• Use of Mixed Methods: The study was limited to quantitative data. However, mixed-method research using qualitative data collection techniques (focus group discussions, in-depth interviews, etc.) could make significant contributions, particularly for a more in-depth understanding of student experiences with digital education applications [13].

• Comparison of Cultural and Institutional Contexts: This study is limited to the Istanbul Gelişim University sample. Conducting similar studies at different universities, particularly among foundation and state universities or in rural/urban contexts, would be beneficial for analyzing the impact of cultural and institutional differences (Hofstede, 2001).

• Comparative Studies Between Fields: Similar digital education applications can be tested in different disciplines, such as healthcare management, engineering, architecture, or social sciences, outside of logistics, to analyze interdisciplinary differences.

• Integration of New Technologies: This study primarily focuses on computer-aided education. Future research should investigate the effects of next-generation technologies, such as augmented reality (AR), virtual reality (VR), and artificial intelligence-supported teaching tools, on career awareness and learning motivation [11].

The Relationship Between Software Types and Learning Levels: Modeling the relationships between the type of software used in education (such as simulation, ERP systems, route planning tools) and students' cognitive, affective, and psychomotor outcomes is recommended.

• Testing Alignment with Employer Expectations: The alignment between students' career awareness development and employers' sectoral digital competency expectations is also an important area to test in the future. In this context, hybrid models based on university-industry collaborations can be developed.

• Curriculum Integration and Use of Digital Modules

Logistics education limited to theoretical knowledge can lead to graduate profiles that are incompatible with the sector. Therefore, it is recommended that digital-based software modules (e.g., domestic transportation, international transportation, air cargo planning programs, etc.) be integrated into curriculum at universities, especially vocational schools. These applications will enhance students' practical competencies and create an industry-ready graduate profile.

• Expanding Career Planning and Digital Literacy Training

The study observed that career awareness levels significantly increased with digital training. In this context, it is recommended that university career centers organize career planning seminars, digital literacy workshops, and simulated case studies aimed at adapting to digital business processes.

• Strengthening Instructor Competencies

For computer-aided education to be effective, instructors must also be proficient in these technologies. Therefore, in-service training programs and competency-building training should be organized for faculty members on the use of digital software modules, evaluation processes, and industry application integration.

• Supporting Mobile and Hybrid Learning Environments

The study demonstrated that the educational process can be successfully carried out on mobile devices. In this context, the development of mobile-compatible digital platforms (e.g., Android/IOS-based logistics application simulators) and the structuring of learning environments in a hybrid (classroom + online) format are recommended. This method will increase student satisfaction in terms of accessibility and flexible learning.

• Strengthening University-Industry Collaborations

Teaching students the software currently used in the industry not only increases academic success but also increases employability. Therefore, protocols and practical training collaborations with logistics companies will support students' sectoral experience and career planning.

• Dissemination of Developed Education Models

The digital education model successfully implemented in this study can be expanded and scaled through pilot testing in various vocational schools and departments. This will enable the creation of a digitalization-based logistics education ecosystem at an institutional level.

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