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Accessibility and Utilization of Artificial Intelligence (AI)-Based Intelligent Tutoring Systems (ITS) and Information and Communication Technology (ICT) In Enhancing Biology Education

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ABSTRACT

This study investigates the accessibility and utilization of Artificial Intelligence (AI)-based Intelligent Tutoring Systems (ITS) and Information and Communication Technology (ICT) tools in enhancing Biology education among university lecturers in Kwara State. A descriptive survey design was employed, involving 44 Biology lecturers across selected public and private universities. The study assessed their awareness, accessibility, and usage of ITS platforms such as BioTutor, Assessment and Learning in Knowledge Spaces (ALEKS), Smart Sparrow, Carnegie Learning's Cognitive Tutor, and Knewton. Findings revealed a moderate level of awareness among lecturers, with Smart Sparrow and ALEKS being the most accessible and frequently used platforms. BioTutor and Knewton showed moderate usage, while Carnegie Learning's Cognitive Tutor was less accessible. Despite existing awareness, challenges related to infrastructure, training, and integration persist. The study recommends professional development programs, improved technological infrastructure, curriculum integration of ITS, and systematic monitoring to ensure effective adoption and application of AI and ICT tools in Biology education.

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1. INTRODUCTION

In an era of rapid technological advancement, the integration of Information and Communication Technology (ICT) and Artificial Intelligence (AI) in education has become essential for enhancing teaching and learning outcomes. For Biology educators, proficiency in ICT and AI tools is crucial to maximizing student engagement and achieving deeper conceptual understanding. Biology, as the study of living organisms and their vital processes, intersects with several scientific disciplines, including chemistry, medicine, and physics (Redish *et al*., 2014). As the complexity of biological science increases, so does the need for practical pedagogical tools that can simplify learning and personalize instruction.

Modern biological science encompasses various subfields, including botany, zoology, morphology, and physiology, all of which are unified by fundamental biological principles. At the molecular level, biology explores the biochemical and energetic mechanisms underlying life (Tansey *et al*., 2013; Hussain *et al*., 2024). The integration of advanced technologies, including ICT-enabled lab instruments and AI-driven analysis tools, has significantly improved the precision and depth of biological research and education (Lamb & Davidson, 2005; Sony & Mcdermott, 2023). The emergence of genomics and other data-intensive subfields further emphasizes the need for digital competence among educators.

Achieving meaningful learning outcomes in biology education depends on a combination of enthusiastic educators, motivated students, effective instructional strategies, and access to technological resources (Nkiko, 2021; Ugbede., 2024). In universities across Kwara State, enhancing Biology instruction requires a shift toward intelligent systems and digital platforms. Intelligent Tutoring Systems (ITS), AI-powered educational tools that simulate human tutoring by adapting to individual learner needs, offer immense potential in transforming the teaching and learning of Biology (Rızvı, 2023; Gocen & Aydemir, 2020). **Figure 1** shows the concept of ITS.

AI is broadly defined as the development of computer systems capable of performing tasks that typically require human intelligence, such as reasoning, learning, and decision-making (Markose & Dewtwal, 2023; Waly, 2024). These systems can process vast amounts of data, identify trends, and deliver personalized feedback rapidly, making them powerful tools in science education. Globally, the use of AI in education is growing, with countries like China and the United States investing billions into AI for educational and economic development (Mou, 2019; Gocen & Aydemir, 2020). Schools must now align with this technological transformation to equip students with 21st-century skills and maintain global competitiveness (Karsenti, 2019).

AI-integrated ITS such as BioTutor, Assessment and Learning in Knowledge Spaces (ALEKS), Smart Sparrow, Carnegie Learning's Cognitive Tutor, and Knewton are specifically designed to adapt to student responses, provide immediate feedback, and support differentiated instruction. These systems can improve knowledge retention, motivation, and overall academic performance (Hemachandran *et al*., 2022; Uzezi & Jonah, 2017). Through modules that simulate teacher-student interactions, ITS platforms assess learner progress, identify gaps, and suggest tailored interventions (Farhan *et al*., 2019; Mahanan *et al*., 2021). This is particularly valuable in complex subjects like Biology, where individualized support can enhance comprehension of abstract concepts (Beyer, 2009; Sokolowski & Ansari, 2018; Allen & Tanner, 2005).

Several studies have examined how university students interact with ITS platforms and have reported positive perceptions, especially regarding adaptive learning features and

feedback mechanisms (Smyrnova & Varchenko, 2022; Bimba *et al*., 2017; Hassan *et al*., 2019). However, research is still needed to understand the level of awareness, accessibility, and actual usage of ITS among university educators, particularly in developing contexts like Nigeria. This study, therefore, investigates the accessibility and use of AI-driven Intelligent Tutoring Systems in revolutionizing Biology education among university lecturers in Kwara State.

The purpose of this study is to assess the accessibility and use of AI and ICT-enabled Intelligent Tutoring Systems in revolutionizing Biology education in universities across Kwara State. Specifically, the study aims to (i) assess university lecturers' awareness of ITS, (ii) examine the accessibility of ITS platforms, (iii) evaluate the use of ITS in Biology education, and (iv) determine the extent to which lecturers utilize these systems. The study contributes to current knowledge by highlighting the practical challenges and opportunities in integrating AI and ICT tools for innovative teaching in Biology, ultimately supporting digital transformation in Nigerian higher education. Research Questions are in the following:

(i) What is the awareness level of university lecturers regarding AI in revolutionizing Biology education in universities in Kwara State?
(ii) What is the accessibility rate of ITS in revolutionizing Biology education among university lecturers in Kwara State?
(iii) What is the use of ITS in revolutionizing Biology education among university lecturers in Kwara State?
(iv) What is the extent of use of ITS among university lecturers for revolutionizing Biology education in universities in Kwara State?

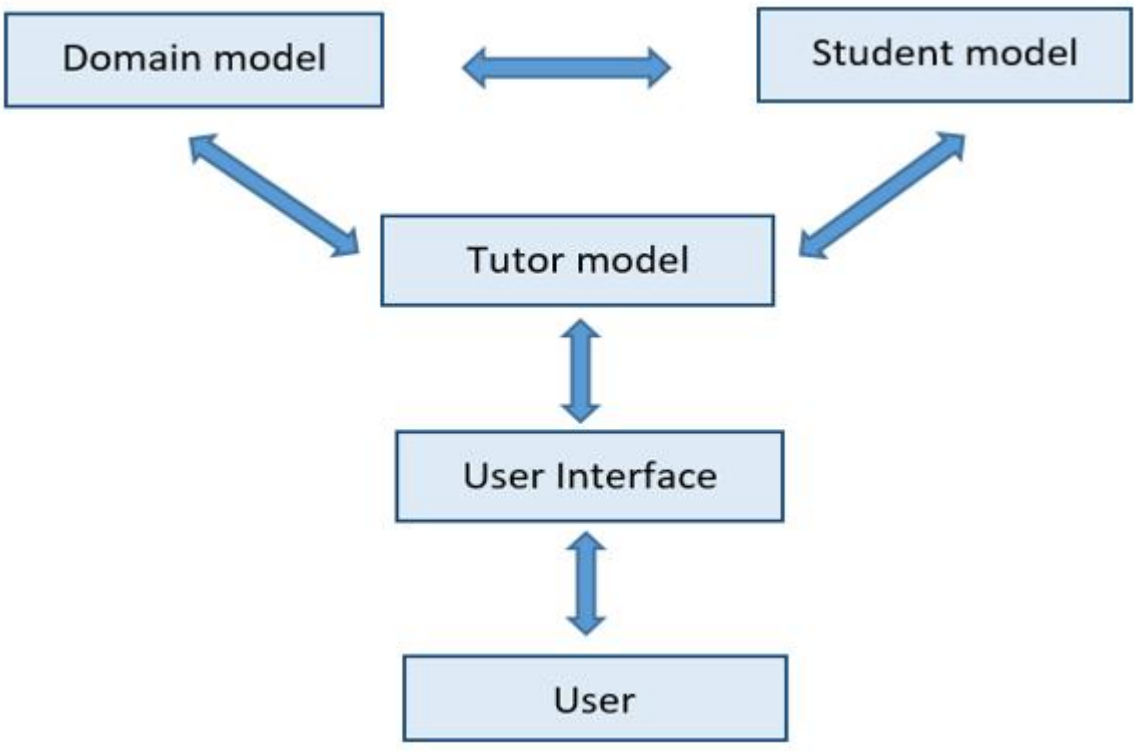

Figure 1. The ITS components.

2. METHODS

This study employed a descriptive research design of the survey type to examine the accessibility and use of AI-driven ITS in revolutionizing Biology education in universities across Kwara State, Nigeria. The target population comprised Biology educators from both public and private universities within the state. A purposive sampling technique was initially used to select one federal university, one state university, and one private university. Following this, convenience sampling was applied to reach Biology lecturers within the selected institutions.

Due to challenges related to distance, safety, and time constraints, data collection was conducted using a digital approach (Taber *et al.,*2020). A structured online questionnaire was designed and distributed through contact persons affiliated with the Departments of Science Education in each participating university. The contact persons were tasked with sharing the survey link on departmental WhatsApp platforms. This method ensured wider reach and participation from lecturers across the selected institutions.

The questionnaire was structured into five sections: Section A focused on demographic information; Section B assessed awareness of ITS; Section C evaluated accessibility; Section D measured the extent of ITS usage; and Section E gathered data on practical application. Each section was aligned with the study's objectives and designed using a five-point Likert scale.

To ensure the instrument's validity, it was reviewed by five experts—two from Computer Science Education, two from Educational Technology, and one from Biology Education. Their suggestions and feedback were incorporated into the final version of the questionnaire. The instrument's reliability was then tested using Cronbach's Alpha, confirming its internal consistency.

A total of 44 valid responses were collected and subjected to descriptive statistical analysis using mean and standard deviation. The analysis focused on answering the four research questions related to awareness, accessibility, use, and extent of use of ITS in Biology education. Ethical considerations were observed throughout the study. Participants were informed of the voluntary nature of their involvement and assured of the confidentiality and anonymity of their responses. Informed consent was obtained through the contact persons who facilitated access to the participants. **Tables 1** through 4 present the detailed analysis of the collected data.

3. RESULTS AND DISCUSSION

Table 1 explains awareness level of intelligent tutoring system in revolutionizing biology education among university lecturers in Kwara.

Table 1 provides an in-depth understanding of the awareness level of university lecturers in Kwara State regarding ITS and their transformative potential in Biology education. A total of 44 lecturers participated in the survey, which assessed their awareness across various dimensions of ITS. The findings indicate that the average awareness level of ITS and their role in transforming Biology education is 3.11, with a standard deviation of 0.993. This suggests a moderate awareness among the lecturers, with responses ranging from 2 to 5. When asked about the specific capabilities of ITS in Biology education, the mean awareness level rose to 3.66, with a lower standard deviation of 0.861, indicating a slightly higher and more consistent understanding of ITS functionalities. In terms of engagement with literature related to ITS in Biology education, the average score was 3.11, with a standard deviation of 0.993. This alignment with the general awareness level indicates a moderate familiarity with relevant literature among the lecturers (Reeves, 2006: Cheng & Teizer, 2013). Regarding the incorporation of ITS into their teaching practices for Biology courses, the mean awareness

level was 3.16, with a standard deviation of 0.963. This reflects a moderate awareness of practical application. The perceived importance of ITS in revolutionizing Biology education had an average score of 3.27, with a standard deviation of 0.788 (Ahmed & Mohammed, 2023; Zhang et al., 2007). This higher mean score suggests that lecturers acknowledge the significance of ITS, though there is some variation in their responses. In summary, the study reveals that while university lecturers in Kwara State have a moderate awareness of ITS and their potential in Biology education, there is a need for improvement. Increased exposure to ITS capabilities, greater engagement with relevant literature, and a stronger focus on practical application could enhance lecturers' awareness and utilization of ITS, thereby revolutionizing Biology education

Table 1. Awareness level of intelligent tutoring system in revolutionizing biology education among university lecturers in Kwara.

Questions	N	Minimum	Maximum	Mean	Std. Deviation
How aware are you of ITS and their role in revolutionizing biology education?	44	2	5	3.11	0.993
To what extent are you aware of the capabilities of ITS in biology education?	44	2	5	3.66	0.861
How frequently are you aware of literature (journals, articles, etc.) related to ITS in the context of biology education	44	2	5	3.11	0.993
To what extent are you aware of incorporating ITS in your teaching practices for biology courses?	44	2	5	3.16	0.963
How important are you aware ITS are in revolutionizing biology education?	44	2	5	3.27	0.788
Valid N (listwise)	44				

The study results in **Table 2** offer detailed insights into the accessibility rates of various ITS in enhancing Biology education, based on responses from 44 participants. The ITS platforms evaluated in this study include BioTutor, ALEKS, Smart Sparrow, Carnegie Learning's Cognitive Tutor, and Knewton. BioTutor received an average accessibility score of 3.34 with a standard deviation of 0.888, indicating a moderate level of accessibility, with participant responses ranging from 2 to 5. ALEKS, on the other hand, had a higher average accessibility score of 3.82 and a lower standard deviation of 0.582, suggesting it is more widely accessible and consistently used by the respondents. Smart Sparrow achieved the highest average accessibility score of 3.91, with a standard deviation of 0.772. This score reflects its broad accessibility and widespread use among the participants.

Table 2. Accessibility rate of intelligent tutoring system in revolutionizing biology.

Questions	N	Minimum	Maximum	Mean	Std. Deviation
BioTutor	44	2	5	3.34	.888
ALEKS	44	3	5	3.82	.582
Smart Sparrow	44	2	5	3.91	.772
Carnegie Learning's Cognitive Tutor	44	2	4	2.55	.548
Knewton	44	1	4	2.41	.622
Valid N (listwise)	44				

In contrast, Carnegie Learning's Cognitive Tutor had a lower average score of 2.55 with a standard deviation of 0.548, indicating limited accessibility and usage. Knewton had the lowest average accessibility score of 2.41, with a standard deviation of 0.622, suggesting it is the least accessible and least utilized platform among those surveyed. Overall, the study highlights the varying levels of accessibility for different ITS platforms in Biology education. While Smart Sparrow and ALEKS are highly accessible, BioTutor shows moderate accessibility, and Carnegie Learning's Cognitive Tutor and Knewton have relatively low accessibility rates. These findings underscore the importance of addressing accessibility issues to ensure the broader adoption and effectiveness of ITS in Biology education. Smart Sparrow, known for its adaptive pathways that respond to student inputs and provide immediate feedback and targeted interventions, received an average score of 3.64 and a standard deviation of 0.917. This reflects a relatively high level of use, with responses spanning from 2 to 5. Carnegie Learning's Cognitive Tutor, which leverages cognitive science research to model student thinking and provide personalized instruction, had an average score of 3.75 and a standard deviation of 1.059. This indicates considerable use among lecturers, with responses ranging from 1 to 5. Lastly, Knewton, which analyzes student interactions with content to identify strengths and weaknesses and delivers tailored instruction and practice problems, had an average score of 3.27 and a standard deviation of 0.899. This signifies moderate usage, with responses ranging from 2 to 5 (see **Table 3**).

Overall, the study reveals varying levels of usage for different ITS platforms in Biology education. ALEKS and Carnegie Learning's Cognitive Tutor are among the more widely used platforms, while BioTutor and Knewton show moderate levels of usage. These findings suggest a growing trend towards the adoption of ITS tools to enhance Biology education, though the extent of utilization varies across different platforms.

In addition, we added the questionnaire used in **Tables 4-6**. This questionnaire is aimed at finding out the Accessibility Rate and Use of ITS in Revolutionizing Biology Education. Students are assured that the data collected will only be used for research purposes and treated confidentially. Students are, therefore, enjoined to please complete this questionnaire as it applies to them. Smart Sparrow, known for its adaptive pathways that respond to student inputs and provide immediate feedback and targeted interventions, received an average score of 3.64 and a standard deviation of 0.917. This reflects a relatively high level of use, with responses spanning from 2 to 5. Carnegie Learning's Cognitive Tutor, which leverages cognitive science research to model student thinking and provide personalized instruction, had an average score of 3.75 and a standard deviation of 1.059. This indicates considerable use among lecturers, with responses ranging from 1 to 5. Lastly, Knewton, which analyzes student interactions with content to identify strengths and weaknesses and delivers tailored instruction and practice problems, had an average score of 3.27 and a standard deviation of 0.899. This signifies moderate usage, with responses ranging from 2 to 5.

Table 3. Use of an intelligent tutoring system in revolutionizing biology education.

Questions	N	Minimum	Maximum	Mean	Std. Deviation
Biology lecturers in universities in Kwara State used a designed BioTutor to help students understand fundamental Biology concepts through interactive lessons and problem-solving exercises.	44	2	4	2.89	0.579
Biology lecturers used ALEKS for a comprehensive curriculum covering topics from basic cell biology to advanced genetics.	44	1	5	3.95	1.120
Biology lecturers used smart sparrow to support adaptive pathways that respond to student inputs, providing immediate feedback and targeted interventions.	44	2	5	3.64	0.917
Biology lecturers used Carnegie Learning's Cognitive Tutor to leverage cognitive science research to model student thinking and provide personalized instruction.	44	1	5	3.75	1.059
In Biology, lecturers use Knewton to analyze student interactions with the content to identify strengths and weaknesses, then deliver tailored instruction and practice problems.	44	2	5	3.27	0.899
Valid N (listwise)	44				

Smart Sparrow, known for its adaptive pathways that respond to student inputs and provide immediate feedback and targeted interventions, received an average score of 3.64 and a standard deviation of 0.917. This reflects a relatively high level of use, with responses spanning from 2 to 5. Carnegie Learning's Cognitive Tutor, which leverages cognitive science research to model student thinking and provide personalized instruction, had an average score of 3.75 and a standard deviation of 1.059. This indicates considerable use among lecturers, with responses ranging from 1 to 5. Lastly, Knewton, which analyzes student interactions with content to identify strengths and weaknesses and delivers tailored instruction and practice problems, had an average score of 3.27 and a standard deviation of 0.899. This signifies moderate usage, with responses ranging from 2 to 5.

Overall, the study reveals varying levels of usage for different ITS platforms in Biology education. ALEKS and Carnegie Learning's Cognitive Tutor are among the more widely used platforms, while BioTutor and Knewton show moderate levels of usage. These findings suggest a growing trend towards the adoption of ITS tools to enhance Biology education, though the extent of utilization varies across different platforms.

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Table 4. Section A: Demographic information.

No	Questions
1	Name (Optional)
2	Gender: Male or Female
3	Academic Rank: Lecturer II, Lecturer I, Senior Lecturer, Associate Professor, or Professor
4	Years of Teaching Experience: 0-2, 3-5, 6-8, or 9 years and above
5	Field of Study/Specialization

Table 5. Section B: Awareness level of university lecturers. it indicates the level of awareness with the following statements using a five-point likert scale (HA = Highly Aware, MA = Moderately Aware, A = Aware, SA = Slightly Aware, RA = Rarely Aware).

SN	Items	HA	MA	A	SA	RA
1	How aware are you of ITS and their role in revolutionizing biology education?					
2	To what extent are you aware of the capabilities of ITS in biology education					
3	How frequently are you aware of literature (journals, articles, etc.) related to ITS in the context of biology education					
4	To what extent are you aware of incorporating ITS in your teaching practices for biology courses					
5	How important do you aware ITS are in revolutionizing biology education					

Table 6. Section C: Accessibility rate of intelligent tutoring system in revolutionizing biology education. it indicates the level of agreement with the following statements using a five-point likert scale. (HA= Highly Access, MA = Moderately Access, A = Access, SA = Slightly Access and RA = Rarely Access).

S/N	Items	HA	MA	A	SA	RA
1	BioTutor: BioTutor is designed to help students understand fundamental Biology concepts through interactive lessons and problem-solving exercises. It adapts to each student's learning pace, providing customized feedback and additional resources to address individual knowledge gaps.					
2	ALEKS (Assessment and Learning in Knowledge Spaces): ALEKS is an adaptive learning platform that uses AI to determine a student's knowledge state and deliver personalized instruction. For Biology, ALEKS offers a comprehensive curriculum covering topics from basic cell biology to advanced genetics.					

Table 6 (Continue). Section C: Accessibility rate of intelligent tutoring system in revolutionizing biology education. it indicates the level of agreement with the following statements using a five-point likert scale (HA= Highly Access, MA = Moderately Access, A = Access, SA = Slightly Access and RA = Rarely Access).

S/N	Items	HA	MA	A	SA	RA
3	Smart Sparrow: Smart Sparrow is an adaptive e-learning platform that allows lecturers to create and deploy customized, interactive Biology lessons. It supports adaptive pathways that respond to student inputs, providing immediate feedback and targeted interventions.					
4	Carnegie Learning's Cognitive Tutor: Originally developed for mathematics, Carnegie Learning's Cognitive Tutor has been adapted for various subjects, including Biology. It leverages cognitive science research to model student thinking and provides personalized instruction.					
5	Knewton: Knewton is an adaptive learning platform that uses data analytics and machine learning to provide personalized education experiences. In Biology, Knewton analyzes student interactions with the content to identify strengths and weaknesses, then delivers tailored instruction and practice problems.					

Table 7. Section D. Use of intelligent tutoring system in revolutionizing biology education. it indicates your level of agreement with the following statements using a five-point likert scale (SA= Strongly Agree, A= Agree, N= Neutral, D= Disagree, SD= Strongly Disagree).

S/N	Items	SA	A	N	D	SD
1	Biology lecturers in universities in Kwara State used a designed BioTutor to help students understand fundamental Biology concepts through interactive lessons and problem-solving exercises.					
2	Biology lecturers used ALEKS for a comprehensive curriculum covering topics from basic cell biology to advanced genetics.					
3	Biology lecturers used smart sparrow to support adaptive pathways that respond to student inputs, providing immediate feedback and targeted interventions.					
4	Biology lecturers used Carnegie Learning's Cognitive Tutor to leverages cognitive science research to model student thinking and provide personalized instruction.					
5	In Biology, lecturers use Knewton to analyze student interactions with the content to identify strengths and weaknesses, then deliver tailored instruction and practice problems.					

4. CONCLUSION

The study concludes that while university lecturers in Kwara State possess a moderate awareness of ITS and their potential in Biology education, there is ample opportunity for growth. By increasing exposure to ITS capabilities, fostering greater engagement with relevant literature, and focusing on practical application, lecturers' awareness and utilization

of these systems can be significantly enhanced. This, in turn, could lead to a transformative impact on Biology education. The study also highlights the varying levels of accessibility for different ITS platforms. Smart Sparrow and ALEKS are highly accessible, while BioTutor shows moderate accessibility, and Carnegie Learning's Cognitive Tutor and Knewton have relatively low accessibility rates. These findings underscore the importance of addressing accessibility issues to ensure the wider adoption and effectiveness of ITS in Biology education. Additionally, the study reveals varying levels of usage for different ITS platforms. ALEKS and Carnegie Learning's Cognitive Tutor are among the more widely used platforms, whereas BioTutor and Knewton exhibit moderate usage levels. This indicates a growing trend towards the adoption of ITS tools to enhance Biology education, though the extent of utilization varies across platforms. Addressing these disparities can further support the integration of ITS in educational practices, ultimately improving the quality and effectiveness of Biology education. Recommendations are in the following:

(i) To improve the awareness level of university lecturers regarding ITS, universities should implement ongoing professional development programs. These programs should include workshops, seminars, and training sessions focused on the capabilities and benefits of ITS in Biology education.

(ii) Universities should invest in the infrastructure and resources needed to make ITS platforms like Smart Sparrow and ALEKS more accessible to all lecturers. Additionally, partnerships with ITS providers could help negotiate better access terms and ensure that platforms with lower accessibility rates, such as BioTutor, Carnegie Learning's Cognitive Tutor, and Knewton, become more readily available.

(iii) To examine and increase the use of ITS in Biology education, universities should integrate these systems into the Biology curriculum. This can be achieved by designing course modules that specifically incorporate ITS tools for interactive lessons, problem-solving exercises, and personalized learning experiences.

(iv) Universities should establish a monitoring and evaluation framework to assess the extent of ITS usage among lecturers. This framework should include regular surveys, feedback mechanisms, and performance analytics to track how lecturers are using ITS tools in their Biology courses.

5. AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. Authors confirmed that the paper was free of plagiarism.

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