Effectiveness of Modern Pedagogy in Big Data Analytics Using Inquiry-Based Learning (IBL)

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***Abstract*— This paper examines the effectiveness of modern methods of teaching with special reference to Inquiry-Based Learning (IBL) in teaching Big Data Analytics to undergraduate students. 57 students participated in the hands-on activities, including poster presentations, learning games with Slido, a quiz with Mentimeter, peer group discussions, and reflective writings in journals. A well-designed survey provided some feedback that these unfamiliar teaching techniques were the key to shaping a deeper understanding of Big Data tools in Hive, Hadoop, and Pig. The students claimed that they felt more self-confident when it came to applying concepts to practice. They also attributed the increase in critical thinking and collaboration abilities. The motivational side is that many students were motivated enough to take additional courses or certifications in data science, and they stated that they would list these experiences in their resumes or during job interviews. The results indicate that IBL in combination with contemporary instructional practices in technical courses should prompt more learning, improved engagement, and improved career preparedness.**

***Keywords*— Big Data Technologies, Inquiry-Based Pedagogy, Experiential Learning, Learner Involvement, Quality Education, Engineering Education, Employability Skills.**

I. INTRODUCTION

OVER the last decades, there has been a tremendous change in the education sector, marked by a shift away from traditional teaching methods and the emergence of a more modern, student-oriented approach, as explained by M. Kryshtanovych et al. (2021). As technology is advancing and the needs of the learners evolve, there is a need to have teaching styles that allow active learning and solving real-life problems described by X. Liu et al., (2020). The conventional lecturing may be an effective means to transfer knowledge. Still, it usually fails to fully involve students and enable them to apply their knowledge in real-world contexts proposed by E. Epaminonda et al. (2022).

Inquiry-Based Learning (IBL) is one of them, and it is aimed at inspiring students to pose questions, seek answers, and develop. Knowledge as a result of inquiry. IBL also leaves traditional rote memorization and provides an opportunity for students to engage in discussions, according to E. B. Boltayevich et al. (2024). Presentations. And a self-reflection process to create knowledge. It also encourages thinking, group work, and self-learning.

The area of Big Data Analytics is a complicated topic that encompasses such tools and platforms as Hive, Hadoop, and Pig, which are essential for industries, as explained by A. Shevchenko et al. (2022). This kind of technical content cannot be taught purely in a theoretical way. With the help of such modern pedagogical approaches as IBL, students will be able to work with such tools in a more practical and significant manner. Quizzes, peer discussions, poster presentations, etc., are activities of this sort as they can narrow the distance between theory and practice described by A. Aggarwal et al. (2025).

In this investigation, 57 undergraduates were enrolled in different interactive learning tasks, which were based on the IBL approach. The involved students participated in activities that enabled them to reason, collaborate, and test by A. Omar et al. (2020). Based on anonymous feedback gauged by surveys, the learners not only had a clearer picture of Big Data tools but also had a higher level of confidence in implementing taught concepts Modern pedagogy, coupled with IBL, would help to

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improve teaching and learning of Big Data Analytics proposed by A. S. Shevchenko et al., (2023) It emphasizes the importance of active learning when developing valuable skills such as critical thinking and collaboration explained by T. Poyasok et al., (2022)

Fig.1 provides the framework that emphasizes the use of Inquiry-Based Learning (IBL) as an effective method for teaching Big Data Analytics to undergraduate students. It starts with a student-centered learning environment that encourages active involvement. IBL is applied through various instructional strategies, such as poster presentations to build research and presentation skills, the use of interactive tools like Slido and Mentimeter for quizzes and games to maintain engagement, and group discussions to promote collaboration and the exchange of ideas. These activities help in developing critical thinking, teamwork, and problem-solving abilities. As a result, students gain a stronger understanding of Big Data concepts, become familiar with practical applications, and are better equipped for professional roles in the field.

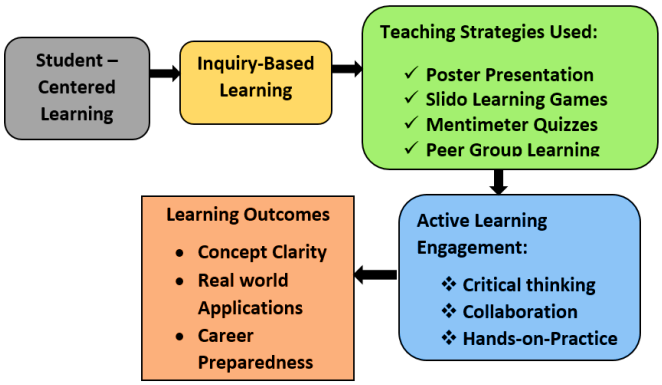

Fig. 1 Instructional Framework: Using Inquiry-Based Learning (IBL) to Teach Big Data Analytics

II. Literature Review

Prainetr et al. (2021) proposed that Digital changes in education are significant to the era of new methods of teaching. Our suggested learning model benefits students in the special economic zones in Thailand and is based on an AI model. In the course of their study, they actively worked on workshop-based learning using Python and IoT to find solutions to real problems. The activities, like role-play, problem-based learning, and community engagement, worked well. Shcherbiak et al. (2022) investigated the role of modern information technologies in making young learners comprehend the concept of success. The authors have presented an educational gadget, namely, a praxeological tale, i.e., the story that teaches children valuable moral lessons and valuable skills. These stories are a combination of fairy tales and life objectives, as well as the development of a personality. The paper revealed the results of the study, according to which digital storytelling may help children become media-bodies and develop well-rounded abilities in life. Zhao (2022) proposed the use of a new approach to enhance online learning systems using innovative technologies. The research dealt with the ability to identify low volumes of speech against background noise, which is a valuable issue in producing understandable online conversations. Chandarana and Shukla (2023) investigated the use of the Outcome-Based Education (OBE) in ensuring that learning graph theory becomes purposeful to the engineering students. Customary instructional practice tends to show limited practical use of graph theory; hence, students do not relate to it. Marinin et al. (2025) focused on the possible role of chatbots regarding the future of digital learning. The article demonstrates that artificial intelligence-based chatbots and their natural language processing capabilities may help the process of learning become more individualized and available.

Aggarwal et al. (2025) explored how modern education has moved away from conventional means, such as self-learning, and towards alternative teaching methods. The research revealed that traditional teaching methods, such as the sage on the stage, are giving way to systems that enable students to learn at their own pace. Shevchenko et al. (2023) studied the process of adjusting Ukrainian engineering education to align with European engineering education using the competence-based approach. Shevchenko et al. (2022) also pointed out the necessity of introducing health-related knowledge to engineering students with value logical disciplines. Courses such as "Health Pedagogy" and "Medical Knowledge" are intended to develop the abilities of students to promote safety, provide first aid, and promote a healthy life. It makes it evident that the two areas, academic and personal health development, should be given equal attention. N. Zaidi et al. (2024) presented the possible ways of transformation of modern teaching methods with the support of technology. It talks about such tools as blended learning, open resources, and flipped classrooms to enhance understanding. Jeyanathan et al. (2024) also described by including the problem-solving techniques as a part of assement which improve students empower and student team achievement.

A. Research Gap and Proposed Framework

While previous research has acknowledged the benefits of active learning approaches in higher education, there is a noticeable lack of focused studies on applying Inquiry-Based Learning (IBL) specifically to the teaching of Big Data Analytics at the undergraduate level. Most existing studies either address broader STEM education or rely on conventional lecture-based methods, offering limited insights into how IBL can be systematically integrated into data analytics curricula.

In addition, the use of interactive digital tools such as Slido and Mentimeter has been explored in isolated cases. Still, there is no well-defined instructional model that combines these tools within a structured IBL framework tailored to technical subjects like Big Data Analytics.

To bridge this gap, the present work proposes a practical teaching framework grounded in IBL principles. This model integrates interactive learning strategies—such as poster creation, real-time quizzes, and collaborative discussions—to support student engagement, conceptual understanding, and application of knowledge. The framework aims to support educators in delivering complex data topics more effectively

while preparing students for real-world analytical challenges.

III. Methodology Framework

A review of the existing literature shows that several instructional innovations have emerged in recent years, including the use of artificial intelligence in education, digital storytelling, outcome-based education (OBE), and blended learning models. These approaches commonly promote student participation, practical application of knowledge, and the integration of technology in the learning process. However, there remains a limited focus on structured, inquiry-driven methods aimed explicitly at teaching Big Data Analytics (BDA) to undergraduate students. To address this limitation, the proposed methodology begins with an extensive review of relevant studies across areas such as competency-based education, early learning through narrative methods, and the use of educational technologies in higher education.

Although digital teaching tools and pedagogical models are widely discussed, a comprehensive framework that integrates these elements within an Inquiry-Based Learning (IBL) structure tailored to BDA instruction is lacking. To fill this gap, a context-specific IBL framework is developed. It incorporates instructional activities such as poster creation, collaborative problem-solving, group discussions, and interactive sessions using platforms like Slido and Mentimeter. The aim is to promote deeper understanding through active involvement and practical engagement. This framework will be introduced in an undergraduate BDA course. Its impact will be measured using student reflections, participation levels, and academic performance, with evaluation tools including structured rubrics and appropriate statistical analysis. The goal is to determine whether this inquiry-oriented approach can improve learning effectiveness and support students in applying theoretical knowledge to practical contexts.

Figure 2 outlines a systematic methodology for applying an Inquiry-Based Learning (IBL) approach to enhance the teaching of Big Data Analytics (BDA) at the undergraduate level. It begins with a literature review that explores current practices in educational strategies such as digital learning methods, outcome-based teaching, and student-focused instruction. From this foundation, recurring educational themes are identified—particularly the need for active participation, practical application of knowledge, use of interactive tools, and assessment strategies aimed at developing relevant skills. The next phase addresses the existing gap: the lack of a well-defined IBL framework suitable for BDA instruction. To bridge this, the model proposes a practical framework that includes the use of posters, digital quizzes, collaborative discussions, and real-world tasks to facilitate meaningful learning. The final stage involves implementing the framework within a BDA course and evaluating its impact through student engagement, feedback, and performance outcomes. This structured approach encourages critical thinking and prepares students for real-world analytical challenges.

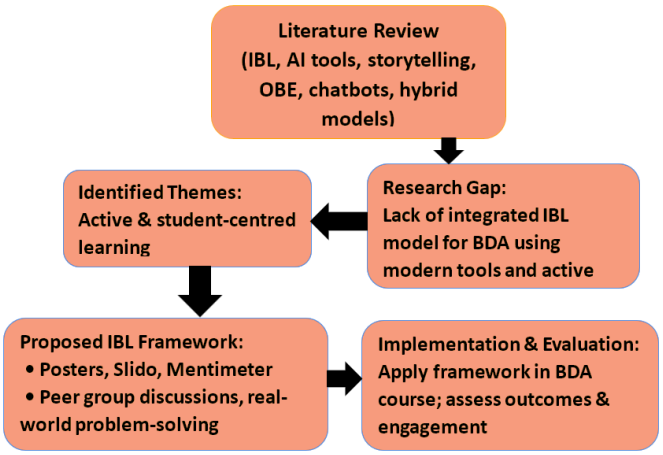

Fig. 2 Design of an Inquiry-Based Learning Model for Big Data Analytics Instruction

TABLE I
OUTLINES A STRUCTURED SURVEY TOOL USED TO EVALUATE TEACHING METHODS AND LEARNING OUTCOMES IN THE CONTEXT OF BIG DATA ANALYTICS EDUCATION.

Table I: ATTRIBUTE AND SUB-ATTRIBUTE DETAILS OF THE SURVEY – MODERN PEDAGOGY IN BIG DATA ANALYTICS

5 – Strongly Agree, 4 – Agree, 3 – Neutral, 2 – Disagree, 1 – Strongly Disagree

Attribute Names	Sub Attributes (Scale Range 1- 5)
Faculty Learning Initiatives (FLI) –Input	The teacher used engaging methods that helped me understand Big Data topics better.
	I was encouraged to ask questions and participate during interactive sessions.
	The teacher connected Big Data concepts to real-world examples and industry trends.
Collaborative Team Involvement(CTI)- Input	Group activities like poster making and quizzes improved my learning.
	Learning with classmates helped me understand tools like Hadoop and Pig.
	Team discussions helped develop collaboration and communication skills.
Tech-Enabled Learning(TEL)-Input	Interactive tools like Slido, Mentimeter, Kahoot, Quizizz, and Padlet helped me remember and apply Big Data concepts.
	Writing reflections helped me relate classroom topics to real-world applications.
	Using digital platforms made learning more engaging and easier to understand.
Learning Skill Assessment (LSA)-Input	Quizzes and games helped me think critically about Big Data.
	I was able to apply what I learned during the evaluation activities.
	The assessment methods helped me identify my strengths and areas to improve.
Enhanced Learning Outcome (ELO)-Output	I feel confident in writing and presenting technical topics.
	The course activities helped me perform better in placements and interviews.

Attribute Names	Sub Attributes (Scale Range 1- 5)
	I am motivated to publish in Scopus-indexed journals and present at conferences.
	I can apply the knowledge gained to real-world problems in the data industry.
	This learning encouraged me to pursue higher studies in Data Analytics.

The survey uses a five-point scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree) and is divided into input and output sections. The input section includes four main attributes: Faculty Learning Initiatives (FLI), which explores how effectively the instructor facilitated understanding; Collaborative Team Involvement (CTI), which looks at the impact of peer interactions; Tech-Enabled Learning (TEL), which focuses on the use of digital tools in the learning process; and Learning Skill Assessment (LSA), which examines how evaluations supported critical thinking and self-awareness. The output section, labeled Enhanced Learning Outcome (ELO), includes five sub-points that measure students' confidence, skill application, academic growth, and readiness for future opportunities. Overall, this table helps link teaching practices with student development, offering a clear view of how modern classroom strategies influence learner progress in Big Data Analytics.

IV. Results and Discussion

The modern pedagogy raises various questions for Inquiry-based Learning (IBL).

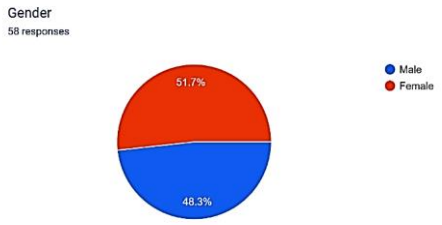

Fig. 3 – Gender Analysis

Fig. 3 displays the gender composition of the 58 participants who took part in the survey. Out of the total respondents, 51.7% identified as female and 48.3% as male. This balanced participation supports a well-rounded understanding of learner feedback, offering input from both male and female students in evaluating the teaching approach used in Big Data Analytics.

Fig.4 presents the residential profile of 58 students who responded to the survey. Of these, 77.6% are day scholars, while 22.4% are hostel residents. The data shows a significant proportion of students commute from home.

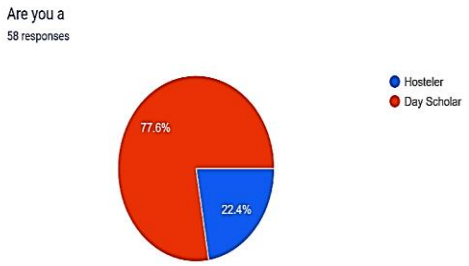

Fig. 4 – Residential Profile

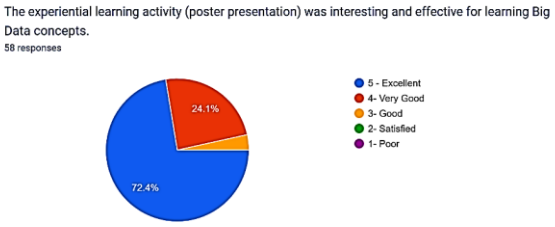

Fig. 5a - Student feedback on a poster presentation

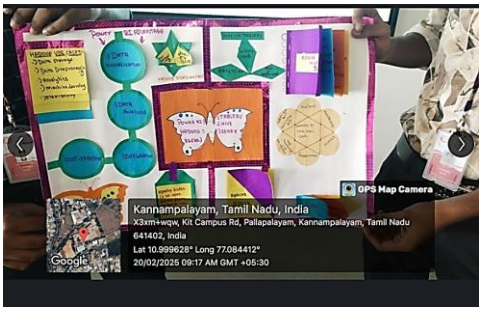

Fig.5b- Students presenting Experiential Learning

Figure 5a illustrates student feedback on a poster presentation activity related to Big Data learning. A majority of respondents (72.4%) rated the activity as "Excellent," highlighting its effectiveness and engagement.

Fig.5b shows active participation in experiential learning through poster presentation, and its impact on understanding the basic and advanced concepts in big data analytics.

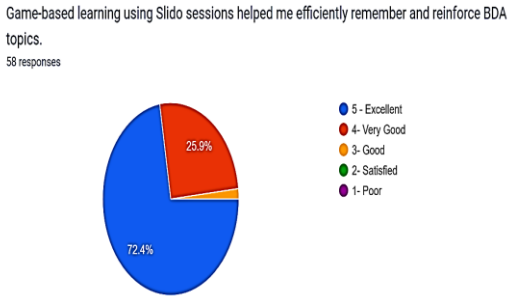

Fig. 6a - feedback on game-based learning

Fig. 6a presents feedback on game-based learning using Slido for reinforcing Big Data Analytics (BDA) topics. A significant majority (72.4%) rated the experience as "Excellent," while 25.9% marked it as "Very Good." This

indicates that the interactive approach was highly effective in enhancing student understanding and retention.

Fig.6b indicates that students' involvement in game-based learning using Slido. Students are enjoying and given more concentration in IBL activities.

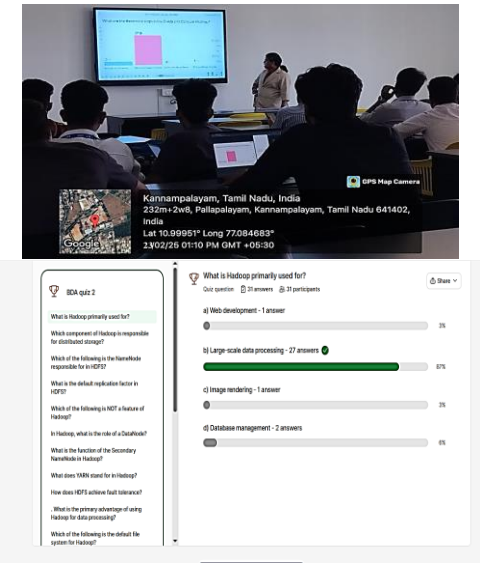

Fig. 6b- Game-based learning using Slido

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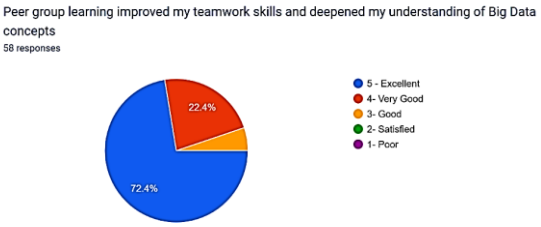

Fig. 7a - The impact of peer group learning

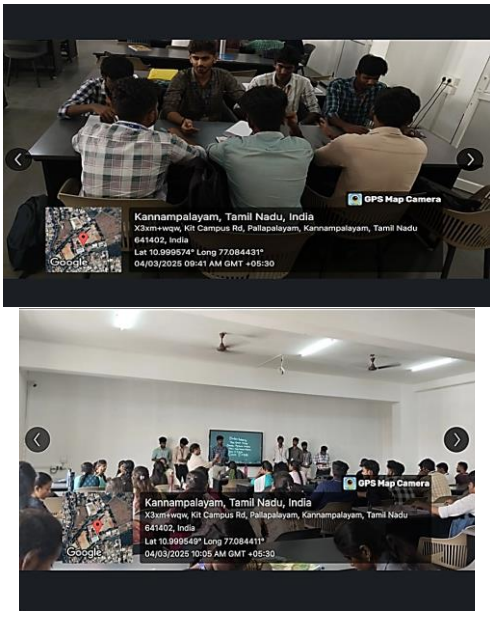

Fig. 7b- Students' participation in peer group learning

Figure 7a reflects student responses on the impact of peer group learning in enhancing teamwork and understanding of Big Data concepts. A dominant 72.4% rated the experience as "Excellent," with 22.4% marking it as "Very Good." This suggests that collaborative learning significantly benefited students' comprehension and interpersonal skills.

Fig.7b depicts the peer group learning constructs, the knowledge, student-led learning, and team spirit in significant data concepts. Sharing knowledge is a critical process in learning.

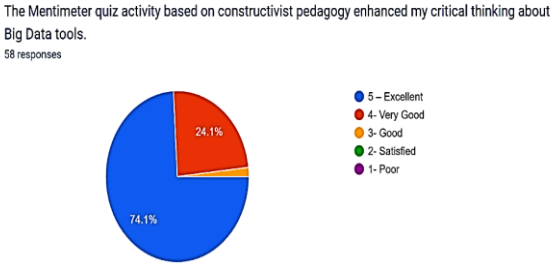

Fig. 8a - feedback on the Mentimeter quiz activity

Figure 8a shows feedback on the Mentimeter quiz activity designed with constructivist pedagogy to enhance critical thinking on Big Data tools. A substantial majority of students (74.1%) rated the activity as "Excellent," and 24.1% marked it as "Very Good." This indicates that the interactive quiz effectively stimulated higher-order thinking among participants.

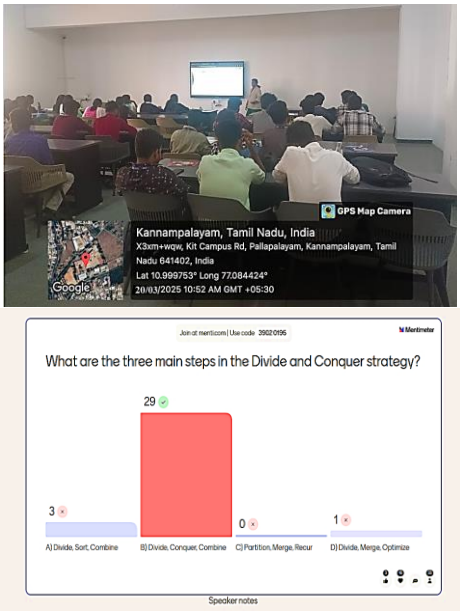

Fig.8b- Students' participation in constructive pedagogy using Mentimeter

Figure 8b explains that IBL-based learning helps in advanced learning rather than memorization for comprehension. IBL demonstrated how constructivist principles can deepen understanding, build confidence, and promote independent and collaborative learning in technical subjects.

Figure 9a depicts students' feedback on journal-based reflective activities focused on Hive, Hadoop, and Pig. A majority of 75.9% rated the activity as "Excellent," while 19% rated it as "Very Good." This indicates that reflective writing significantly enhanced their understanding of the practical applications of Big Data tools.

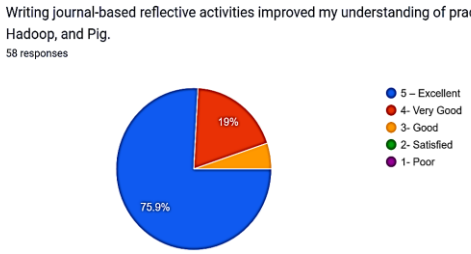

Fig. 9a - students' feedback on journal-based reflective activities

Fig.9b –Students' participation in journal-based article writing in big data

Fig. 9b describes the Research Article Writing activity as an impactful modern pedagogy intervention that blended theoretical understanding with academic inquiry and real-world relevance. Students emerged more confident, research-oriented, and critically engaged.

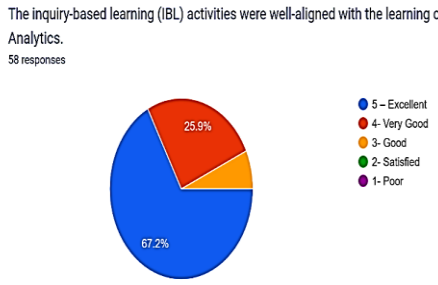

Fig. 10 - Student feedback on the alignment of Inquiry-Based Learning (IBL) activities

Figure 10 presents student feedback on the alignment of Inquiry-Based Learning (IBL) activities with Big Data Analytics learning objectives. A majority of 67.2% rated the activities as "Excellent," while 25.9% chose "Very Good." This indicates strong approval of the IBL approach in meeting course goals effectively.

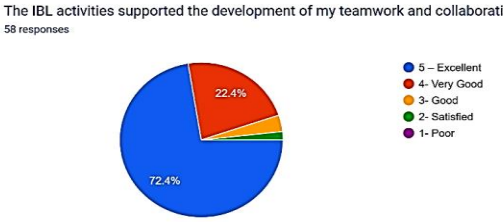

Fig. 11 – Students' feedback: Inquiry-Based Learning (IBL) Activities enhanced their teamwork and collaboration skills

Figure 11 illustrates students' feedback on how Inquiry-Based Learning (IBL) activities enhanced their teamwork and collaboration skills. A substantial 72.4% rated the support as "Excellent," with 22.4% selecting "Very Good." This suggests that the IBL approach was highly effective in fostering essential collaborative competencies among learners.

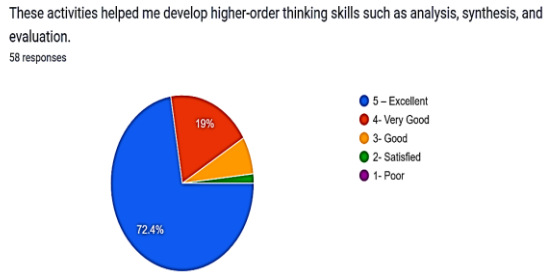

Fig. 12 - Student feedback on the effectiveness of activities in developing higher-order thinking skills

The Fig. 12 pie chart presents student feedback on the effectiveness of activities in developing higher-order thinking skills, such as analysis, synthesis, and evaluation. A majority of 72.4% rated the activities as "Excellent," followed by 19% who marked them as "Very Good." This indicates a substantial positive impact of the activities on enhancing critical and analytical thinking among students.

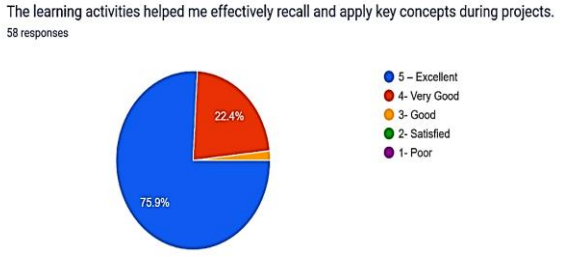

Fig. 13 - students' feedback on how learning activities supported their ability to recall and apply key concepts during projects

The Fig. 13 pie chart shows students' feedback on how learning activities supported their ability to recall and apply key concepts during projects. A large majority, 75.9%, rated the support as "Excellent," and 22.4% rated it as "Very Good." This reflects the substantial effectiveness of the activities in

enhancing practical application and retention of knowledge.

Fig.14 shows that experiential learning helps in placement interviews; mostly, students who have prepared for the interview will find it very helpful.

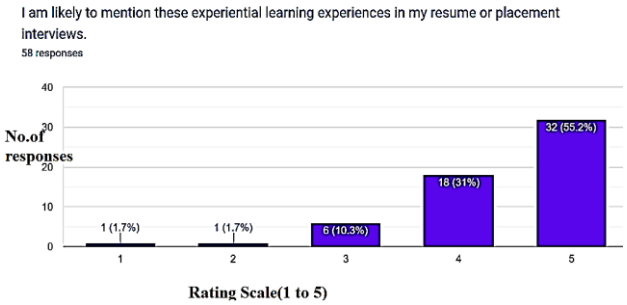

Fig.14- Students' experiential learning impact

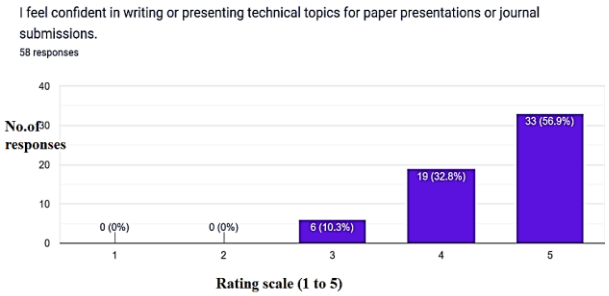

Fig. 15- Confident analysis of students in presentations

Fig.15 describes the modern pedagogy where IBL plays a vital role in research, including paper presentations and journal publications.

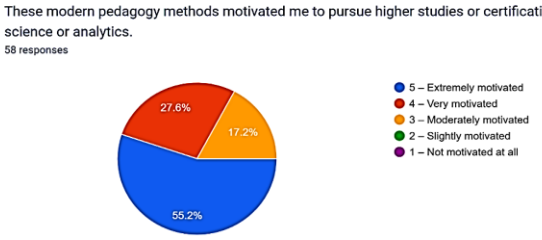

Fig. 16- Modern pedagogy's impact on higher education

Fig.16 explains the impact of modern pedagogy on encouraging higher studies and completion of high-end certificate courses such as NPTEL, Coursera, etc.

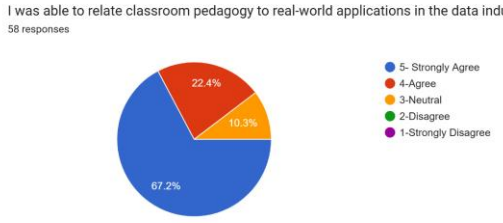

Fig.17- IBL in Industry connection

Fig.17 explains that classroom pedagogy helps students connect with industry and solve real-world problems, and helps them explore more real-world applications.

Fig. 18 connects modern pedagogy in entrepreneurial opportunities where students can start their businesses and analyze customer requirements for data analysis.

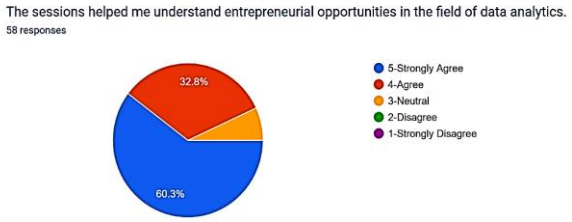

Fig.18 – IBL impact on entrepreneurial opportunities

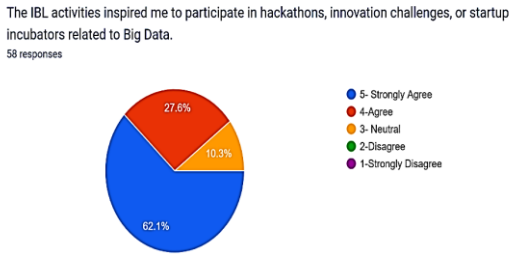

Fig.19- IBL activities in external participation

Fig.19 explains that IBL helps in participation in more hackathons, ideathons, innovation challenges, startups, hackerrank, etc. It improves students' confidence more and more.

V. CONCLUSION

The study reveals that the integration of Inquiry-Based Learning (IBL) with active teaching strategies positively influences student learning outcomes in Big Data Analytics. Participation in various hands-on and collaborative activities enabled students to gain practical skills in technologies such as Hive, Hadoop, and Pig. Furthermore, the approach contributed to the development of essential competencies, including critical thinking, teamwork, and self-assurance in applying theoretical concepts. Many students expressed a willingness to explore the field through additional certifications further, recognizing the relevance of these experiences for their future careers. These outcomes suggest that incorporating IBL into technical education can significantly enhance student engagement, knowledge acquisition, and career readiness. This approach promoted independent learning and a stronger sense of responsibility towards mastering complex topics.

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