Integrating Complex Aviation Science Projects into Undergraduate Engineering Education with Dialectic Design Approach and Comparative Performance Analysis for Innovative Practices

I. Dabipi
Department of Engineering and Aviation Sciences
University of Maryland Eastern Shore
Princess Anne, Maryland, USA
ikdabipi@umes.edu

Willie L. Brown, Jr.
Department of Engineering and Aviation Sciences
University of Maryland Eastern Shore
Princess Anne, Maryland, USA
wlbrown@umes.edu

Lei Zhang
Department of Engineering and Aviation Sciences
University of Maryland Eastern Shore
Princess Anne, Maryland, USA
lzhang@umes.edu

Christopher Hartman
Department of Engineering and Aviation Sciences
University of Maryland Eastern Shore
Princess Anne, Maryland, USA
chartman@umes.edu

Abstract— **Engineering students are challenged with implementing and developing systems within STEM disciplines. The dialectic design approach and comparative performance analysis were created for undergraduate engineering students as a teaching method to facilitate and improve student-learning experiences in STEM disciplines. We had found in our study that both the dialectic design approach and comparative performance analysis are critical to the theoretical development and the fundamental practices for engineering education in course learning objectives. These teaching methods were created for undergraduate engineering students to support specific interdisciplinary practices such as aviation sciences and course objectives focused on emerging issues concerning the design process and performance analysis. An undergraduate engineering course must promoted student-learning experiences for innovative practices through engineering models and performance analysis. The integration design in this course supported areas that include complex aviation science projects and the requirement constraints for system development.**

Keywords—Aviation Science Projects; Engineering Education; Interdisciplinary Education; Dialectic Design Approach; Comparative Performance Analysis

I. INTRODUCTION

The educational framework to facilitate the relationships between dialectic design and comparative performance analysis are critical for undergraduate engineering students. This framework has adopted a systematic approach that will addressed the adequacy of findings required to support the complexity of project development. The approach to integrate both the dialectic design and comparative performance analysis are implemented to reveal potential shortcomings within the STEM disciplines based on a theoretical process [1]. The dialectic design and comparative performance analysis will identify existing relationships in the development phase and draw attention with regard to the lack of an adequate perspective concerning complex project such as aviation science systems [1]. This is meaningful in the undergraduate engineering student education process to understand the creation and structure of developing theories used to analyzed related issues and debates within a STEM area [1]. The study applied the dialectic design and comparative performance analysis to support the practical viewpoint of the grounded theory approach and the perceptions of undergraduate engineering students addressing complex aviation science projects. The dialectic design and comparative performance compromise of the fuzzy techniques for evaluating student-learning outcomes and the decision-making approach based on complex aviation science projects. The study relevance was to use the grounded theory process as a potential method for demonstrating the importance of adaptation in learning success. For the success of student-learning outcomes and objectives, the expectations of future implications among undergraduate engineering students were measured to assess specific design approaches and integrated methods concerning complex environments. The research measures were assessed and evaluated using existing empirical findings and the implementation design that undergraduate engineering students considered. The students' considerations were managed to address complex aviation science projects and the sociological challenges in system development within the education framework. .

The undergraduate engineering education standards are complexed, particularity in meeting the demands and requirement conditions for development within STEM interdisciplinary. The actions used for development were

The authors are with the School of Business and Technology, Department of Engineering and Aviation Sciences at the University of Maryland Eastern Shore, Princess Anne, Maryland.

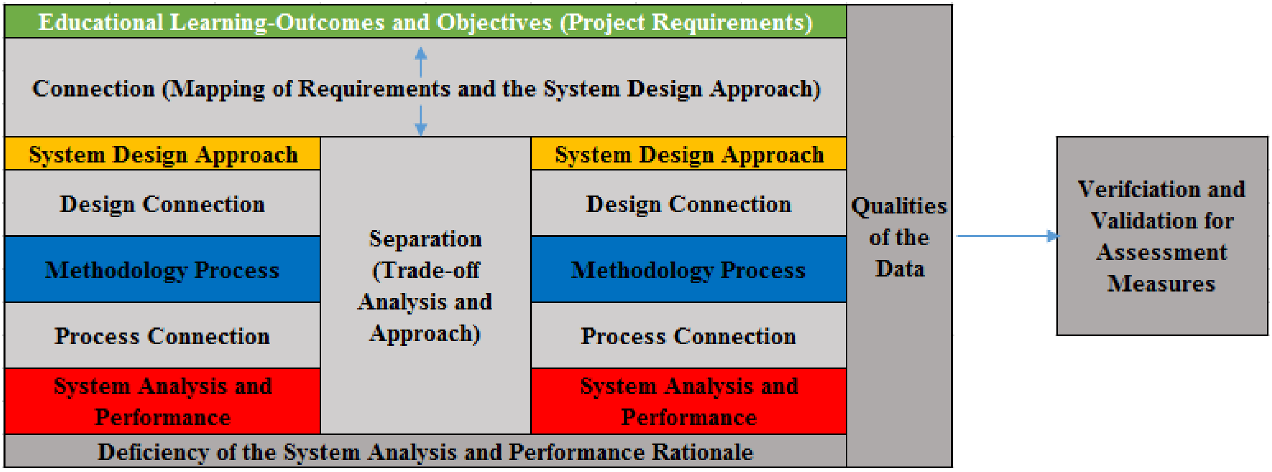

Fig. 1. Education learning-outcomes and objectives with assessment measures to support a design framework of system connections for mapping requirements using system analysis and performance rationale based on verifcation and validation .

created to support the system requirements, design, implementation and deployment process by managing guidelines and practical implications. This process also highlighted course measures and criteria for undergraduate engineering students [2]. The standards were conceptualized to support the undergraduate engineering students' outcomes from the Accreditation Board for Engineering and Technology (ABET) criteria. The ABET criteria and student-learning objectives were strategized to provide a method that maps how undergraduate engineering students can learn innovative approaches from a novel situation involving complex system development.

The study's contribution explains how integrated complex aviation science project into undergraduate engineering education with dialectic design approach and comparative performance analysis for innovative practices could draw on factors of model-theoretical philosophy perspective and standards. The dialectic design and comparative performance analysis were developed to support undergraduate engineering students by exploring factors of educational goals, expectation and desires for system development. These factors consist of literature review findings, anticipation of end-product changes, prototypes, benchmarking, risk concerns, prioritizing requirements, and mitigating risk in system development [1], [2]. The study aims to bridge the requirements with the understanding of design practices and the complexity of practiced for system development.

II. Dialectic Design Approach and Comparative Performance Analysis

The dialectic design approach and comparative performance analysis are depended on the ability to construct and capture the key requirements of STEM practices [3]. This section includes the variety of complex phenomena based on the diffusion of innovation, strategy and knowledge for information flow in data collection [3]. The objective for the dialectic design approach and comparative performance analysis was to provide a systematic explanation of theory development, which covers areas within modeling choices, study design, data sources and data collection, theory-building, analysis of structural and behavior [3]. The data collection method provided a nuance, variation, and connection in the project practice to enhance measures contributing to the emerging of a theoretical framework for education evaluation [3]. This framework used traceability matrixes to link empirical data and the relationship of undergraduate engineering students with complex aviation science projects [3]. In the figure above, the requirements were mapped to connect and separate empirical findings of the system design approaches, the methodology process, system analysis and performance to educational-learning outcomes. The mapping of project requirements to educational-learning outcomes and objectives were implemented to support the decision-making process for system development and rationalization of trade-offs and implementation deficiencies. The educational framework was deployed to explore and investigate through fieldwork research the intersubjective practice by presenting requirements for potential findings that support verification and validation (e.g., assessment measures). These potential findings were linked to connect and map key attributes needed to assess the distinctiveness of each requirement measure [4]. Note that the dialectic design approach was integrated to support these requirement measures. However, the system implementation process was evaluated using the comparative performance and analysis to map requirement measures (i.e., data findings) to educational outcomes and objectives for undergraduate engineering students. The results of the design approach and decision-making process led to the evaluation of complex aviation science project findings help to assess the criteria that support student learning outcomes and objectives for system validation. This framework was designed to guide undergraduate engineering students and provide specific strategies in order to examine the contradictions, inconsistencies, and ambiguities of aviation science platforms and related STEM practices. Whereas, the guide to support the framework for assessment of functional requirements (e.g., failures) and the information results were used to bridge the gap for alternative innovative practices.

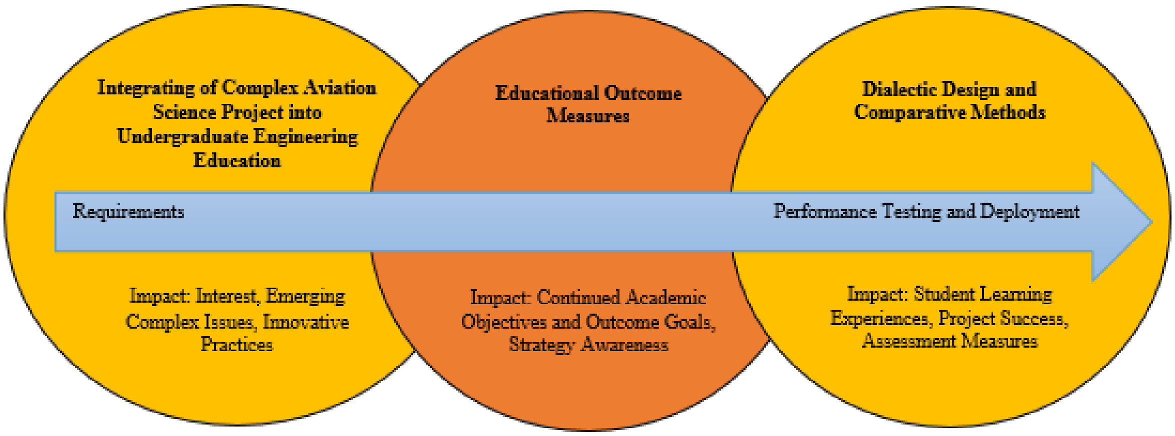

Fig. 2. Educational framework supporting the interaction and impacts based on dialectice design approach and comparative methods for engineering development practices.

A. *Dialectic Design Approach*

The dialectic design is recognized as the approach in system development to led design-science research paradigm at the core from multiple views using knowledge goals given a specific process [3], [5]. For complex design-science research methods, the novelty of undergraduate engineering students must be justified and the issue of how knowledge in the STEM area is proceed. The dialectic design approach is frame to concisely addressed complex project issues and helps overcome the barriers that hamper the emergence if design-science into innovative practices [5]. The paradigm embraces contradictory principles and the design process for student learning outcomes [3], [5]. The key principles were used for conducting, justifying, and evaluating complex aviation science projects. The key principles of the dialectic theory include [5]:

- Social construction is created to take in account the business model and the environment constraints, influences and cultural dynamics for education effectiveness based on requirements (or actions)
- Totality is the system level qualities and the components by examining the conditions and manner of interactive dynamics underlying complexity of the system design
- Contradictions focus on the different viewpoints and the challenges that are opposed in the instruction activity for analysis

These principles were meaningful and the knowledge gained from undergraduate engineering students through the analysis of a given design problem (i.e., synthesis of solutions) supports the evaluation process for education goals and objectives [5]. The concept brings to the fore the core relationship of specific qualities and the interdependences between theory and practice [1], [5]. The dialectic design process in nature aligns with the perspective and the approach that supports the educational practices and will be critical to undergraduate engineering students learning outcomes and objectives.

The challenged with deploying systems in environments are mostly do to the interface requirements and the manner in which the system will interact with other systems. The first dialectic theory mentioned is the social construction principle. Social construction principle explores how the understanding of the role allows for system evaluation for planning through dialectical interplay of specificities of each requirement and interacting systems [6]. The perspective in the dialectical interaction of design requirements are linked with strategic approach (e.g., system scope and societal context) [6]. The strategic approach was a perspective used to provide a relational of a particular environment and take account of the various course of actions and constraints [6]. The dialectal approach foci are on the structure and integration of system within specific environments. For complex aviation science projects, the field is highly regulated and undergraduate engineering students must take into account the implications of the design approach with regard to system integration.

The totality principle is the second dialectic theory that provided a coherent and holistic viewpoint at the system design level. The importance of empirical investigation and the effectiveness involving the totality helps to identify requirements and the design implementation process factors [6], [7]. Realigning pedagogy efforts to model factors of the totality in the design approach created a higher level of understanding in the characteristics of the research problems and examining the system's shortcomings [6], [7]. This design is a guide to a practical solution to formulate the necessary requirements to address the quality in the decision making process [7], [8]. In order to examine the totality based on requirements, the system design must take into account the effectiveness of each component and influences for measurability concerning complexity. This principle can strengthen the requirements that were addressed from the perspective of effectiveness by formulating different conditions

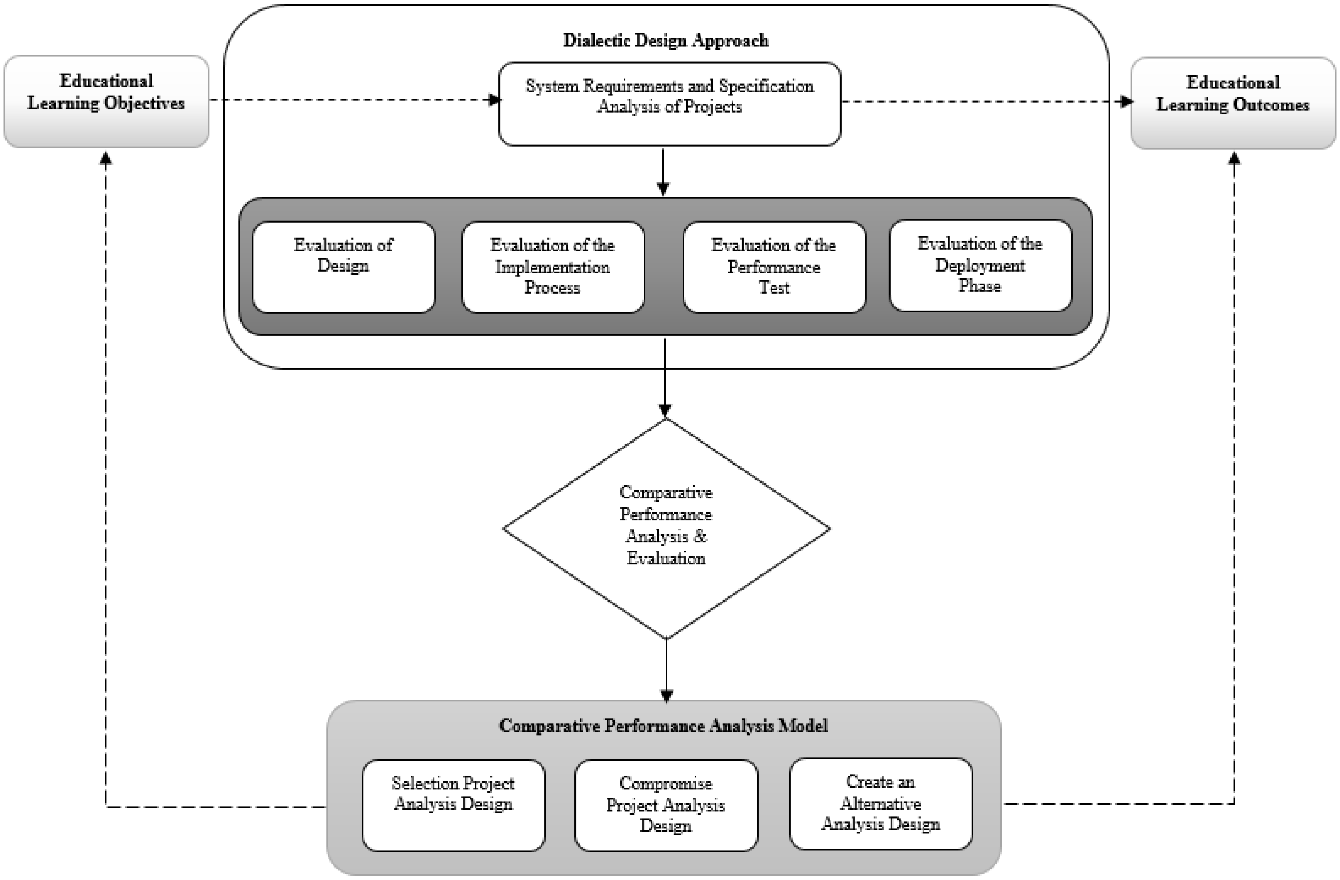

Fig. 3. Educational framework supporting the interaction and impacts based on dialectice design approach and comparative methods for engineering development practices.

The contradictions principle in education practices is the third principle and is essential to the dialectic philosophy. The dialectic process offered undergraduate engineering students the logic to understand and discovery various pathways supporting a pedagogical practice for innovation. This pathway helped undergraduate engineering students to interpret information and manage the different techniques that will benefit their project development practices [10]. The principle also promotes dialogue and an abstract knowledge for development while expanding learning potential within a classroom environment. The undergraduate engineering students valued the social context and the learning outcome findings increased through innovative practices while using the contradictions principle. Utilizing the contradictions principle reduced the complexity in the aviation science project for undergraduate engineering students and the challenges opposed in the instructional guidelines for analysis. These guidelines represented the influence factors of the student learning outcome and objective (e.g., ABET criteria) that were necessary to the integration process for STEM disciplines and system requirements [10], [11]. In addition, the contradictions principle influenced in STEM education practices were relevant to the scientific investigation in analyzing different areas of interests concerning complex aviation science projects [11]. This created a specific approach that improved As a result, the principle helped bridged the gap and validate the education aptitude by exploiting and embracing the strategy for development.

B. Comparative Performance Analysis

The undergraduate engineering students' results were part of a case study in order to compare the effectiveness of the learning process with regard complex aviation science projects. The comparative performance analysis was integrated to model design methods and the systematic process of comparing the perspectives of undergraduate engineering students involving learning outcomes, specific performance analysis and common characteristics [12]. The comparative performance analysis was used to clarify an array of analytical techniques and the data analysis of undergraduate engineering students. This was relevant in order to explore innovative practices and the completion of the project from beginning to end with assessment measures. The comparative performance analysis supported the aspect of requirement analysis, particularly in meeting the demands that were necessary for project development and product satisfaction. These demands were essential to the development strategy for functionality and implementation influences. The concept was also important to undergraduate engineering students in identifying ways to increase innovative practices to address design standards. This method assessed the performance of the project findings for advancement and long-term success through validation (i.e., input and output variables).

The fuzzy logic is important for the comparative performance analysis in terms of input and output variables [13]. The inputs and outputs of the comparative performance analysis will always be values (i.e., current inputs and changes as it relates to outputs). The current state and system change were described with the following set of differential equations:

$$\frac{d[x_i]}{dt} = \sum_{j=1}^{m} f_{i,j}(\mathbf{x}), \quad \text{for} \quad i = 1, \ldots, n, \tag{13}$$

were each function describes a different process (e.g., transcription, translation, etc.) and has set parameters (e.g., transcription rate, translation rate, etc.) [13]. The comparative performance analysis of fuzzy logic using composition control of binary addressed input and output parameters [13]. Using this logic, the functions that were only partially know due to missing parameters were replaced:

$$\frac{d[x_i]}{dt} = FL_k(\mathbf{x}) + \sum_{j=1}^{m} f_{i,j}(\mathbf{x}),$$
$$\text{for} \quad i = 1, \ldots, n \quad \text{and} \quad k \neq j, \tag{13}$$

where FL_k (x) is the logic model of the process for which parameters are unknown [13]. The inputs are model and the values of the comparative performance analysis output were combined for simulation and evaluation.

As a result, the comparative performance analysis investigated the best techniques by aiding innovative design approaches and capabilities. Performance analysis was a part of system testing and support complex environmental factors such as aviation applications. The comparative performance analysis was valuable to the implementation phase and gives solutions based on predictable outcomes. The fuzzy technology was utilize within the practical applications to compute output functions and values for complex aviation science projects. Complex aviation science projects are challenged with uncertainty that relates to technology performance in environments and development. These challenges were related to safety and ethical concerns in aviation and aerospace systems operation. This provided a confidence and the tradeoff for effectiveness-supported safety by engineering modeling and computing practices. For complex aviation science projects, the operational design and testing are important and through simulation in order to verify real-time performances were integrated within the educational goals and objectives. The educational goals and objectives were evaluated and the fuzzy logic created awareness among students in terms of comparative performance analysis. The comparative performance analysis reinforced the behavior and the structure for modeling, simulating, and implementing distinctive methods that support system qualities in complex aviation science projects.

III. Method

The purpose is to examine undergraduate engineering students' perceptive with complex aviation science projects using the dialectic design and comparative performance analysis as a case study. The case study focused on the principles of data collection, analysis and reporting of undergraduate engineering students' outcomes. The assessment of student learning outcomes identified advantages and limitations aimed to provide insight for improving student learning experiences. The goal is to gather and analyze data by uncovering the root causes that affect undergraduate engineering students and complex projects. The research method was consistent with the undergraduate engineering students' performance and evaluation. The undergraduate engineering students received survey questions to create a better understanding in promoting the educational goals and objectives based on knowledge, skills, and acceptance of the dialectic design approach and comparative performance analysis with complex aviation science projects (see figures and table below).

In the case study, the authors had access a target population by seeking permission to conduct the study on undergraduate engineering students within the university setting. The population consists of twenty-five (25) undergraduate students and their contribution to achieve the purpose of the study findings involving complex aviation science projects. considered population. The authors in this study gather information to ensure that insights of the population were accurately represented in the study. The feedback from the 25 undergraduate engineering students was used to ensure the reliability and validity of the proposed theory and method. The participation of the undergraduate engineering students were entirely voluntary and the individuals were not coerced into taking the survey. The participants were also reminded that each question is voluntary and the participants were allowed to withdraw at any time. The same participants were involved both in the pre and post survey questions for assessment purposes.

The survey questions were a critical component of the study in addition to the student learning outcome evaluation results. The results of the survey from the undergraduate engineering students' perspective were used to analyze information-based responses to change the approach and learning style delivery. The value in the study indicates changes that were adapted to meet educational goals and objective for undergraduate engineering students. The approach and method provided flexibility to undergraduate engineering students and identified environmental measures based on aviation science project findings. This study also explored possible reason why student-learning gaps may exist between STEM interdisciplinary due to the challenges and knowledge faced in project understanding and development process.

IV. Results and Discussion

As part of the result and discussion section, the dialectic design approach and comparative performance analysis model were constructed for the used of integrating complex aviation science projects into undergraduate engineering education. The university's institutional review board (IRB) approved the survey questions supporting human subject findings. The results of the study report the design solution in different contexts along with research outcomes. The sample consisted of twenty-five (25) undergraduate engineering students, both male and female. In the pre and post survey questions, the integration of complex aviation science projects in undergraduate engineering education with dialectic design approach and comparative methods were administered in a traditional classroom setting.

The analysis of the outcomes from both contexts demonstrated analytic and theory development involved the twenty-five (25) undergraduate engineering students and their engagement in complex aviation science projects. The dialectic design findings led to the development of a broader theory and improved educational findings for assessment. The theoretical understanding about the undergraduate engineering students engaged in complex aviation science projects also led to a comparative analysis due to missing variables. This improved the student learning process through the requirement phase to deployment based on educational objectives and outcomes. The results from both approaches indicated that students demonstrated valued in using the theoretical approaches to develop a supportive learning community in STEM practices. However, the study was only limited undergraduate engineering student and their involvement with aviation science projects and did not involve other related STEM disciplines. In addition, the limitation in study was based on undergraduate student practices and the criteria outcomes of ABET. Hence, the assessment measures and findings supported outcomes for integration within STEM education practices.

TABLE I. THREE DIMENSION CROSSWALK: INTERGATING OF COMPLEX AVIATION SCIENCE PROJECTS INTO UNDERGRADUATE ENGINEERING EDUCATION WITH DIALECTIC DESIGN APPROACH AND COMPARATIVE METHODS FOR SURVEY ASSESSMENT MEASURES

Three Dimensions Mapping	**Crosswalk: Integration of Complex Aviation Science Projects into Undergraduate Engineering Education with Dialectic Design Approach and Comparative Methods**	
	Assessment Measures	***Survey Questions***
Technical Dimension	*Effectiveness*	Do believe that this undergraduate research experience is effective in improving life-learning practices with regard to integrating complex aviation science issues into engineering education based on the dialectic design approach and comparative performance design?
		How effective is the dialectic design approach and comparative methods in determining an overall system design?
		How effective does the dialect design approach and comparative methods in revealing strategies for educational reasoning by linking relevant application practices to emerging issues?
Interpersonal Dimension	*Knowledgeable*	How knowledgeable are you on the issue in aviation and the design requirement of the proposed system?
		How knowledgeable are you about the limitations such as trade-offs and risk by using the dialect design and comparative analysis approach within emerging education?
		Please indicate your level of knowledge in engineering prior to the start of the course about complex aviation science projects.
Reflective Dimension	*Helpful, Satisfied*	How helpful is the dialect design and comparative methods used as a learning experience to support across disciplines in engineering education based on course learning objectives and student learning outcomes for ABET standards.
		Overall, do you believe the dialectic design approach and comparative analysis were helpful for integrating issue using complex systems such as aviation science?
		Overall, are you satisfied with the dialectic design approach and comparative analysis used as a learning method for engineering education?

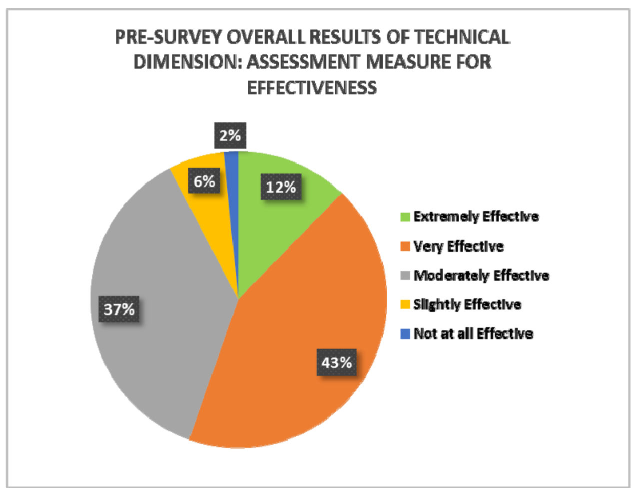

Fig. 4. Pre-survey overall results of the technical dimension and the use of effectiveness measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

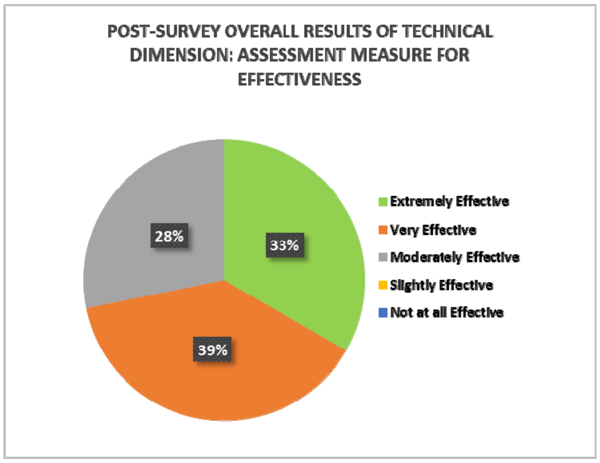

Fig. 5. Post-survey overall results of the technical dimension and the use of effectiveness measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

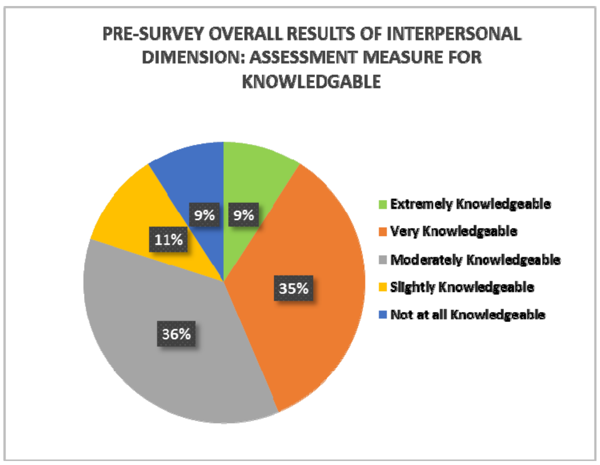

Fig. 6. Pre-survey overall results of the interpersonal dimension and the use of knowledgable measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

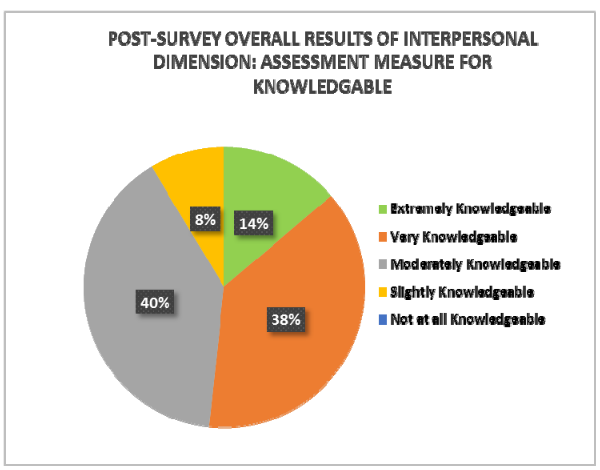

Fig. 7. Post-survey overall results of the interpersonal dimension and the use of knowledgable measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

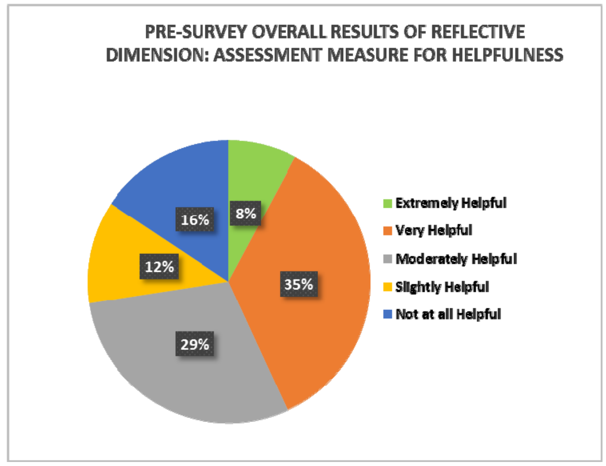

Fig. 8. Pre-survey overall results of the reflective dimension and the use of helpfulness measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

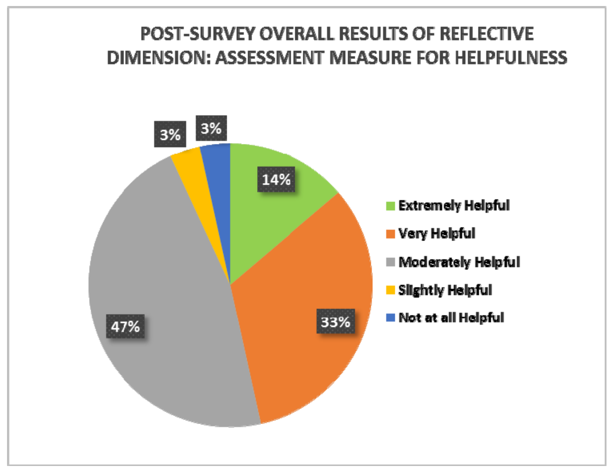

Fig. 9. Pre-survey overall results of the reflective dimension and the use of helpfulness measures to integrate the dialect design approach and comparative methods for undergraduate engineering students

Overall, the integration process of complex aviation science projects for undergraduate engineering students with dialectic design approach and comparative analysis found the content relevant and students valued the opportunity to engage in the educational research. We had aimed to categorized the results for evaluation in three theoretical dimensions (i.e., technical, interpersonal and reflective) reinforcing the design in order to determine key aspect for modeling purposes (see figures and table above) [14]. The survey data and comments made by students were based on project experiences and the existing framework noted in the study. These activities were analyzed to determine the validity of the theoretical dimensions and to highlight further implications and perception of students. The comparisons made included accessing and evaluating findings as well as the planning pathway in the study. The results were used to bridge the gap of complex aviation science project for undergraduate engineering student by providing insight and interconnections in related STEM disciplines. The overall results were based on pre-survey and post-survey in the three dimensions (i.e., technical, interpersonal and reflective) and the findings in this discussion had a significant effect on undergraduate engineering students and their experience involving complex aviation science project using the specified methods and designs

V. Conclusion

In exploring the dialectic design approach and comparative methods for educational purposes, the undergraduate engineering students gained insight by engaging in practical application designs and explored potential findings that supported system requirements with course learning outcomes. This approach reveals how teaching strategies using education reasoning were linked relevant to the application practices. The integration of complex aviation science projects into undergraduate engineering education created an avenue to explore a specific interdisciplinary in STEM education by promoting awareness in system design efforts and performance evaluation. This awareness identified to undergraduate engineering students about emerging issues within the field of practice. These emerging issues encouraged students to translate theory into practice based on findings.

The implications in this study has been key to define ranking criteria (i.e., technical, interpersonal and reflective) using the dialectic and comparative performance analysis [13]. The key findings for future implications presented ways to integrate specific interdisciplinary experiences into undergraduate engineering education based on the dialectic design approach and comparative performance analysis for innovative practices. The practices also allowed model-theoretical philosophy to draw on factors of awareness with regard to perspective (e.g., decision-making process) and educational standards (assessment measures). The decision-making process and the evaluation in a fuzzy environment were considered to assess aviation science projects using the dialectic model and comparative performance analysis. The fuzzy logic findings were key to identify set parameters, method accuracy, problem objectives, discriminative measures and inconsistency [13, 14]. The education standards (assessment measures) were studied using complex aviation science projects, which comprised of the fuzzy logic. These findings were important to the decision-making process for separation that supports methods using trade-off analysis in ranking specific criteria. The outcome in the trade-off analysis also determines the problem from different perspectives using (e.g., technical, interpersonal and reflective) with regard to the dialectic and comparative performance model.

Overall, the evaluation process using dialectic modeling and comparative performance analysis were designed to inspire undergraduate engineering students in a complex interdisciplinary practice. The benefits in developing and synthesizing a design method that addressed theoretical challenges are vital to the engineering education process for data collection and assessment. This study offered specific guidelines for theory building driven-by students using a systematic approach in engineering practices with undergraduate engineering education. The student learning experiences with STEM interdisciplinary practices such as aviation could cultivate and foster a detail approach in the classroom among peers needed to investigate complex emerging issues. The most relevant contribution of the study could be summarized through integrating methods and design measures using strategies adopted to model a theoretical framework, which is suited for undergraduate engineering students engaging in complex interdisciplinary practices. As a result, the undergraduate engineering students were prepared to engage in a specific interdisciplinary learning experience (i.e., aviation science) to support innovative practices using the dialectic design approach and comparative performance analysis methods based on faculty evaluations of each course-learning outcome and course objectives.

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