The Integration of Data Analytics to Assess Multi-Complex Environments of Research to Practices in Engineering Education

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***Abstract*—The integration of data analytics in engineering education to address technical requirements from a multi-complex environment perspective concept will explore areas of research to practices category in regards to the current work in progress using data analytics tools (e.g., IBM Watson Analytics). The results obtained from a multi-complex environment have aided students and improved their decision approach to quantify data accuracy and project requirements in education practices for predictive learning. In using the data sets developed from Watson Analytics, this assembly of display in multi-complex environments provided students with the ability to assess and understand the visual presentation to determine predictive models in data exploration. Data exploration was used to identify a research approach in the education assessment of the multi-complex environments of engineering students' projects. The multi-complex environments and the variables assessment also provided insight with an understanding of project requirements and objectives using data visualization techniques and decision relationships gained from data exploration. This approach investigated the learning methods and decision practices through pattern recognition, educational objectives and course outcomes in specific multi-complex environments with efforts supporting research to practices. The integration of analytics tools with regard to decision-based learning allowed the engineering students the ability to forecast requirements and create new methods critical to their engineering design. This was significant due to the students' ability to model decisions in a manner that experts had challenged engineering education using research to practices to address aspects of the multi-complex environments based on industry standards. This technique had also improved the practical implication for student learning and the decision methods to support research in engineering education with regard to predictive learning and modeling design methods. (*Abstract*)**

Keywords—Learning Analytics, Multi Complex Learning Environments, Engineering Education, Integration, Research to Practices (*key words*)

I. Introduction

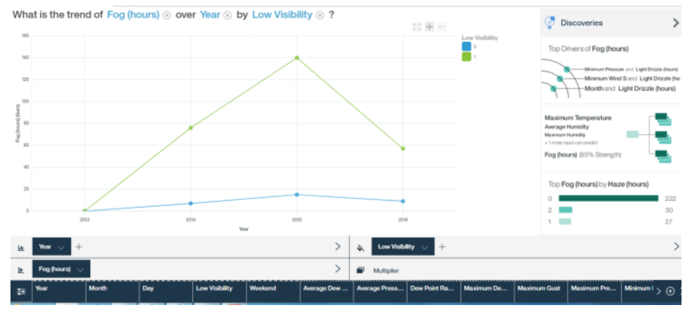
The dataset provided using Watson Analytics to predict requirement demands for the assessment in engineering education allowed decision-based learning methods to be modeled and identified specific conditions, limitations and constraints using descriptive analytics. The description of the variables recognized trends with the use of predictive modeling in multi-complex learning environments. This created an understanding to improve learning outcomes in specific areas and the challenges presented in engineering education through forecasting using decision-based learning. The approach required the use of education-learning objectives proposed using a set of questions and presented attributes assigned to variables with specific conditions and protocols. The set of questions posed also allowed for the integration of predictive analytics in engineering education and the user in the environment to explore and expand on the information that affects the specific variables presented in the question. In this study, the use of decision-based learning method for new discovery set of natural language in IBM Watson Analytics created modeling techniques for data visualization. The techniques for data visualization in Watson Analytics allowed for predictive analytics to model attributes and concepts from the viewpoint of the practice involving research. This had allowed students to gain insight based on the implication posed from the data analysis as a result, students are able to assess the project demand through predictive analytics using decision-based modeling.

The engineering students had investigated the effectiveness of decision-based learning methods using specific tools to frame the decision environments concerning functional requirements in engineering education projects. The specific tools used to frame a structure and the decision environments introduced project challenges to model the underlined conditions and influences of engineering practices. This was essential in addressing the proposed challenges and methods in decision management to model appropriate instances of engineering practices and education outcomes. The decision-based learning method was critical in a multi-complex environment to coordinate and manage the various aspect of performance. In engineering education, the ability to solve problems with decision-based learning methods focused on the understanding of students to investigate problems in an ideal manner according to experts [1]. This assessment of multi-complex environments improved the feedback and the understanding of the proposed problem with a predictive analytic tool by providing answer from existing information significant to the data response [1]. The students were given a multi-complex project using a predictive analytic system to draw a relationship to engineering concepts. The subsidiaries of a multi-complex environment were built to the decision-making requirements using a project design for predictive learning. This study explored the advancement in engineering education and the research needed to examine decisions in a manner that experts addressed the interdisciplinary practices and design requirements for innovation.

II. Data Exploration And the Research to Practices In Engineering Education

The engineering students were tasked to investigate predictive modeling methods using operation flow related to flight operations with low visibility due to weather phenomenon. The dataset provided using Watson Analytics to predict demands with weather data of engineering design purposes created new findings with data exploration. The study and discoveries had supported engineering concepts in human factors with regard to the project requirements involving system design constraints. Data exploration and the decision-based learning process included areas in engineering practices that challenged routes concerning delays, cancellation, capacity and traffic flow. The engineering students on the project design combined of aerospace engineers, computer engineers, mechanical engineers and electrical engineers. The engineering students integrated

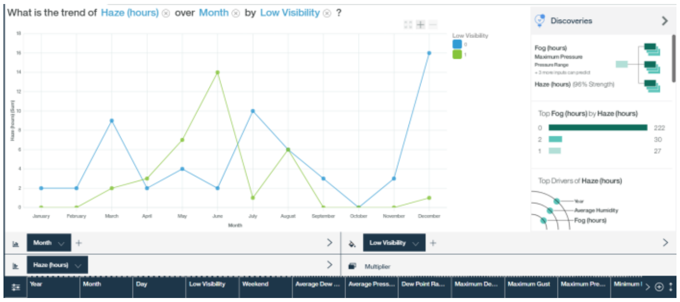
Fig. 1. Requirement Conditions Using Data Exploration by Watson Analytics



human factors concepts, which had allowed them to investigate and predict demands of the proposed project design for data analytics in order to improve performance-based navigation with weather data. The approach required students to understand the requirements, conditions and constraints that supported a decision-based learning process design for research to practices. The data in the decision-based learning process examined specific requirement, condition, and constraint descriptions using data visualization, trends and predictive modeling. The data exploration concept allowed the engineering students to find new discoveries and variables used in the requirements design.

In performing data visualization with engineering students, the approach introduced new discoveries by forecasting techniques to improve methods about education goals and to explore the specific learning objectives [2]. These objectives were aligned with the learning outcomes in engineering education practices and the decisions were supported to address the specific requirements and design of project needs to improve efficiency. The concept of data exploration and the research to practices in engineering education using data visualization identified areas on what was the leading caused and challenges in the project requirements and learning outcomes. This was important in understanding the conditions and attributes that are affected certain performance measures in engineering education. Data exploration also provided questions concerning the conditions in accordance to the predictive demands of Watson Analytics to assess tool in multi-complex environments. In the data exploration, the initial set of questions posed by Watson Analytics provided a baseline with data visualization examples and findings of the engineering practices and requirements. This approach advanced the knowledge and methods to gain insight of each new discovery set in natural language format. The insight was important for engineering students in their examination of aviation and aerospace engineering practices and the effects of weather in flight operation (i.e., engineering aircraft performance to support low visibility due to specific weather challenges and designs). The database provided the user with information to explore and expand on the effects of the specific variables presented in aircraft designs related to fog (see Figure 1). The engineering students were able to explore set requirements based on the conditions and aircraft environments in their design models. For example, one of the initial set of questions posed by Watson Analytics was the following:

FIG. 2. DATA EXPLORATION AND THE CONCEPT OF TRENDS FOR RESEARCH TO PRACTICES BY WATSON ANALYTICS



What is the trend of fog (hours) over year by low visibility? In this example, the datasets were highlighted using the variables from the database provided.

From the example, the engineering students were able to address requirements around the natural of this specific question and attributes concerning aircraft design measures. The engineering students were challenged to explore the months, weeks, and days of specific operation due to performance requirements from the specific design model. This was important for the students design model to understand system aircraft design due to low visibility and weather challenges such as fog in aviation operation. The engineering of aircraft systems also discovered challenges in time constraints of weather and wind research. Not only, tool with the newly explored discovery allowed for student designs to be support by a multi-complex environment in engineering, but also it improved the students understanding to model their designs for development specific factors from the engineering requirements. This development of a new question provided insights about the trend within the system design that addressed haze (hours) over month by low visibility (see Figure 2). Watson Analytics answered and provided specific months that haze could be a problem in the potential design due to aircraft systems and the issues in predictive demands. The experiment with the available filters and visualization options were important to the overall students' education learning outcomes. The outcomes models were tested using the students' ability to engineer a design with the set defined drivers from the local filters and datasets supported by the tool's calculation. The tested results and its implications were all posed from the question of data exploration using requirements to support aircraft designs in engineering education and the challenges concerning specific requirements in performance research.

The decision-based learning process expanded on the understanding of flight operation and specific factors included specific variables identified in the data sets based on the predictive demands of engineering in research to practices. The ability to examine the content of data that included methods of data cleansing aided in the development of a decision-tree prediction model concerning the engineering design. Learning outcomes and measures were studied in engineering education and evaluated using the proposed conditions and environments revealed in understanding requirements of a multi-complex environment [3]. Data exploration also revealed a decision-tree prediction model and the influenced of potential design challenges and conditions dependent from the proposed design requirements for research to practices [4]. The dependency of requirement conditions provided the engineering students with ways to discover specific factors and predictive models that allowed them to explore the independent variables, which was a significant influenced in their engineering education experience for research to practices [4].

III. METHODS OF INTEGRATION WITH PREDICTIVE MODELING

The developments of the question to predict demands with Watson Analytics were examined and the specific variables of predictive modeling in engineering education methods presented valuable results. The method used to aid in the project design with predictive modeling for integration included continuous (interval) target variables. This allowed students to explore new developments and findings with respect to the project designs that created the level of details needed to gain insight of specific test results using predictive modeling and behaviors. The results and solutions were also used to detect hidden trends aided in the understanding to predict demands and requirement design results for implementation testing and integration.

The target type for the continuous variable and model included three outcomes and methods – linear regression main effect, linear regression interaction effect, and CHAID regression tree. Data exploration in the initial question does not produce a continuous variable target type. Therefore, in the education approach, the method to integrate a question with predictive modeling has to be changed and implemented using modeling variables (e.g., the one-variable model and the two variable models). The desired results to recognize the relationships between variables using the specific requirements were supported by the complexity of the system design requirements. Since the challenge to produce a continuous variable using the dataset to address the requirement design henceforth, the engineering students were able to identify the relationships between specific variables by assessing the data obtained. For engineering education, this observation allowed to create an engineering design appropriate with methods using regression models and data obtained from exploration to understanding system integration of multi-complex environments. In the engineering students' assessment, they identified the top (5) five best methods found in their education experiences with the analysis to identify key methods with regard to design requirements. These methods included:

- Check the dataset and the requirement design for testing of the results;
- Implement specific requirements in format of the question based on visualization types and the relationships associated with the system design;
- Align the dataset questions to the defined system design requirements for potential assessments (this learning outcome will be important to the project design);

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- Design models should be implemented to drill down in details for an effective data analysis when using the proposed methods;
- Deploy a methods using the various target types that will provide data inputs and outputs for modeling (this will ensure that the requirements are supported by the data analytics results for predictive modeling).

These five methods were served as the engineering students' approach for implementation of the project design using datasets with visualization types in their practical experiences to integrate system environments. The methods were also developed to guide students with the analysis process by assessing the finding and results in order to understand data requirements and new discoveries of design performance measures. The methods identified how data assessment and the classification of applied predication models are critical in improving the accuracy within the test results and findings. This applied predication model and approach known as confusion matrix using the concept of data assessment. The concept provided statistical classification based on the specific indictors in data analytics of the multi-complex environments for performance measures.

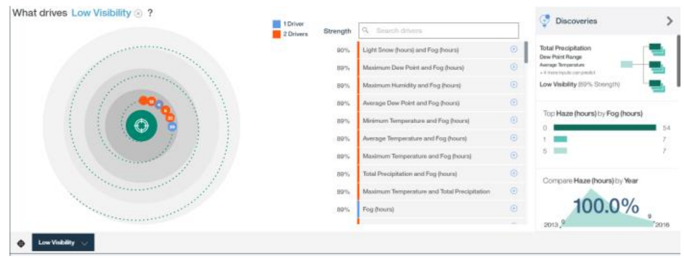
In the next section, this proposed method and concept were used to predict the environmental outcomes and test design results provided by the confusion matrix using categorical (discrete) target variables. The proposed method further the engineering students' insight, which they had gained from this section. This had provided ways to simplify values using the categories of statistical classification. The categories of statistical classification included categorical (discrete) target variables using confusion matrix, which described how test results and learning outcomes in the education practices were presented in natural language (e.g., with a simplified - yes and no meaning). The proposed learning methods and categories of statistical classification with the integration of data analytics were essential for students in their understanding of the system design requirements using Watson's Natural Language. The approach provided correction to predictions and the test result measures before addressing the implementation phase in students' engineering design process.

IV. Data Analytics and the Test Results

The project design results were initially broad and the data analysis allowed for the improvement of data quality in testing the engineering design (i.e., with the use of natural language for visualization modeling). Since many datasets are limited, the consideration to include data analysis tools such as Watson Analytics allowed students to expand their dataset models and they had created additional models that were available to support their project design. To understand and examine the project requirements, the students had to improve their education experiences from a broader concept to a narrow scope to address the problem design with a solution for research to practices.

The following questions were examined: *What drives Low Visibility?* The predict demand with the data using Watson Analytics was first presented in a spiral visualization type. In using only one driver out of the two, the data was drilled down to *fog (hours)* as a factor. This analysis identified that *fog (hours)* was a key driver of *low visibility.* In the statistical details, low visibility was a categorical target (so a logistic

FIG. 3. PREDICTIVE ANALYSIS USING THE FILTERS OF TEST RESULTS BY WATSON ANALYTICS



regression based approach used) with a predictive strength (classification accuracy) at 89% and the records included 1,100 (100%). The model comparison test results; whereas, the following chi-square (187.08), df (3), and sig. (<0.0001). The distribution test results for *fog (hours)* range from 0 to13 and chi-square 17.45 to 90.67 with a defined sig. (<0.0001) for each value. From this question, the engineering students were able to explore results and consider a design concept based on fog at certain times of the day for aircraft lighting systems in below (see Figure 3).

With the same analysis, the following question was expanded, which had included: *What is a predictive model for Low Visibility,* the decision rules show that *total precipitation* and six (6) other inputs predict *low visibility* This was also filtered by *fog (hours)* and *low visibility*. Using the decision tree, the upper tree explained from the initial total precipitation inputs of maximum humidity and dew point range with year. The lower tree explained from the initial total precipitation inputs of average temperature and maximum temperature with average humidity. The results from the predictor were important to using the factors of project design engineering students would have to consider such as total precipitation (0.56 value), maximum humidity (0.16 value), average temperature (0.11 value), average humidity (0.09 value), maximum temperature (0.04 value) and dew point range (0.03 value).

The first model results showed the predictive models of predict demands; hereafter, the study was able to draw a conclusion with regard to engineering concepts and the factors using a decision tree. This approach led engineering students to identify, which specific areas are needed and the contributing factors based on the project design models. Second, the inputs provided a detail statistical analysis about the dataset for predictive modeling, which is limited in many traditional approaches within the education environment. The performance assessment results using multiple visualization types were then understood with specific best practices, models and methods found in the decision-tree analysis. Lastly, the results created a model for development in engineering education and served as a baseline for data analysis and examination. The project design discoveries identified with Watson Analytics natural language the scope of implementation required to perform a set design.

FIG. 4. UPPER TREE RESULTS OF PREDICTIVE MODELING BY WATSON ANALYTICS

FIG. 5. LOWER TREE RESULTS OF PREDICTIVE MODELING BY WATSON ANALYTICS

Overall, the specific factors included and the variables identified from the decision-tree and the engineering students were able to examine the results in order to predict requirement design demands using Watson Analytics (see Fig, 4 and 5). The engineering students had the ability to explore the content of data that included new discoveries for data cleansing and methods to aid in the development of a decision-tree prediction model results and findings. In these results and findings, the data quality had a major effect on the frequency of events and variable associations. Whereas, a specific event or combinations of events incurring together presented the lowest frequencies in the datasets. The events that had high granularity also yielded a low frequency rate [5]. The emerging data using the upper and lower tree results for information processing explored the conditions in this study and the various aspects supporting the engineering students and their specific knowledge. The knowledge gained from the data analytics presented results, which had allowed students to create an engineering design process for their project design based on set conditions, limitations, and practices. This approach allowed the engineering students to proceed with the system design using the engineering requirements for research to practices. They are currently using these variables gained from this study to aid in their engineering design process concerning a multi-complex environment for system development using these results and findings.

V. CONCLUSION

The use of predictive modeling to observe the necessary input of performance and trajectory needed to adopt an approach were important in the success of research to practices in engineering education. This approach was established and adopted with a multi-complex environment using requirement designs and models derived from data related to engineering projects in an education setting [6] [7]. The findings allowed engineering students to have a different viewpoint, which was critical to the understanding of specific datasets and approaches. The value of these approaches also allowed for the engineering students to compare models at the various conditions and perspectives that supported the system design process in integration. Whereas, these attributes were not discovered in a traditional approach using the engineering lifecycle; but it was based on the data analytics, and the ability to address concerns in a multi-complex environment by linking relationships of system designs and performance requirements. However, the engineering students noted that this approach had created more than one interpretation of data in the engineering design process. This interpretation of data was studied using the methods to correlate and align the proposed factors due to the project scope and requirement specification. In the engineering students' ability to identify new findings and outcomes, they had presented advantages of linking the new discoveries to the proposed requirements and factors with each concept. This was important in defining how multi-complex environments could also present multiple viewpoints in engineering requirements within the project design. The disadvantage from the engineering students' perspectives was how the findings could present the potential effect of narrowing the scope with the likelihood of multiple outcomes in the decision model. This disadvantage was more evident in the application design and the engineering students (in the study) were able to discuss both the pros and cons of a multiple outcome approach.

This study was designed to present how data analytics could be useful in engineering education and the concepts of data refinement. In this study, the engineering students are able to understand the requirements through data modeling from the presented concepts with viewpoints of the project design. The analysis was helpful for extremely complex designs due the temporal changes; however, the design with only a few relationships could be difficult due to the level of detail presented. Moreover, the relationships in multi-complex environments with regard to engineering education can create specific challenges in system integration. This study allowed the engineering students to uniquely analyzed the system environments and requirements based on the ability to perform the different levels of granularity between datasets [6]. This opportunity using visual analytics and techniques are explored to understand how datasets and the method to categorize specific attributes are studied using related tools. This can aid with the engineering design process in particularly among areas needed to be defined and modeled regarding the engineering decision making approach. This yields in improving the engineering requirements and measures to support research to practices and decisions with regard to learning outcomes and objectives [7].

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