Using Active Learning, Group Formation, and Discussion to Increase Student Learning: A Business Intelligence Skills Analysis

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ABSTRACT

This paper describes the process used to integrate active learning, group formation, and classroom discussion in a college-level business intelligence class. To assess the impact of active learning and discussion on learning outcomes, we captured student performance on their final data challenge term project across increasingly collaborative and discussion-based sections. To stimulate reflective discussion and to promote cooperative and collaborative teamwork during in-class assignments, we established small groups based on an incoming business intelligence-related skills self-assessment. Our regression results indicate that a skills-based group formation approach enabled an enhanced level of in-class assignment completion and promoted reflective discussion in the classroom. We also find that active learning and discussion increased appropriation of business intelligence concepts and analytical tools. The inherent nuances of business intelligence education, as well as the implications and strategies for improved classroom discussion in a technology class setting, are reviewed.

Keywords: Active learning, Discussion, Groups, Business intelligence

1. INTRODUCTION

Big data is described as the most significant technology disruption in business and academia since the introduction of the Internet. The demand for big data, data analytics, and Business Intelligence (BI) skills has increased rapidly as data storage costs have continued to drop and data capture continues to rise (Agarwal and Dhar, 2014). The Quant Crunch: How the Demand for Data Science Skills Is Disrupting the Job Market, published through a partnership between IBM, Burning Glass Technologies, and the Business Higher Education Forum, discusses this increasing demand for professionals skilled in Data Science and Analytics (DSA) and urges a requisite response from higher education.

Higher education is responding and is increasing DSA course offerings. DSA courses with the highest percentage increases between 2011 and 2016 are Big Data/Analytics (+583%), Data Visualization (+300%), Business Data Analysis (+289%), and Business Intelligence (+260%) (Mills, Chudoba, and Olsen, 2016). These new course offerings reflect the current industry demand for college graduates with the skills to manage the increasing volume, variety, and velocity of data, and for managers who apply descriptive, predictive, and prescriptive analytics to decision making (Chen, Chiang, and Storey, 2012).

Demand for these skills is supported by research indicating companies in the top third of their industry in the use of these new skills are, on average, 5% more productive and 6% more profitable than their competitors (Brynjolfsson and McAfee, 2011). As college level DSA instruction increases, so does the need to understand the most effective pedagogical approaches.

Instruction on the topic of business analytics differs from instruction on many other IS topics because, in addition to learning appropriate tools and techniques, students must also learn to become data-driven decision makers (Jeyaraj, 2019) in increasingly collaborative organizational environments. The relevance of collaborative organizational environments is confirmed by Wixom et al. (2014) who found that the top skill desired by employers when making BI/BA hiring decisions is communication. While SQL, statistical tools, and database concepts remain important, Topi (2019) emphasizes a need to broaden our understanding of the IS environment, describes the role of IS as a collaborating discipline, and includes collaboration and teamwork as core competencies for IS education. Effective active learning pedagogies increase and enhance student interaction (Conduit et al., 2017) and help develop a student's ability to collaborate effectively, thereby helping students gain an enhanced understanding of both BI skills and organizational communication processes.

The Association to Advance Collegiate Schools of Business (AACSB) has also increased its recognition of the importance of DSA in managerial decision-making. In a recent (2018) standards update, AACSB added a section to Standard 9 requiring undergraduate and graduate business school programs to include "technology agility" throughout the curriculum. The proposed 2020 standards add a required table to demonstrate that technology is "appropriately infused" throughout the program (AACSB, 2020). AACSB standards define technology agility as:

> Evidence-based decision making that integrates current and emerging technologies. These include the application of statistical tools and techniques, data management, data analytics, and information technology throughout the curriculum as appropriate; ethical use and dissemination of data, including privacy and security of data; understanding of the role of technology in society, including behavioral implications of technology in the workplace; demonstration of technology agility and a "learn to learn" mindset, including the ability to rapidly adapt to new technologies; and demonstration of higher-order cognitive skills to analyze an unstructured problem, formulate and develop a solution using appropriate technology, and effectively communicate the results to stakeholders. (AACSB, 2018)

The increased focus on data analysis skills by industry and the requirement to include technological agility in a business school's curriculum by accreditors create a complementary increase in the importance of assessing student learning in DSA courses to develop a better understanding of how to achieve the best outcomes. This paper explores the use of active learning and classroom discussion as pedagogical approaches in the development of a student's understanding of big data concepts. We examine the use of classroom "engagement by design" (Riordan, Hine, and Smith, 2017) techniques to increase skills achievement in the application of appropriate tools and analytical approaches to decision making using business intelligence tools.

2. LITERATURE REVIEW

We investigate student learning in the context of an undergraduate BI course. The course learning objectives and requirements are consistent with the skills required for big data and analytics instruction identified by Mills, Chudoba, and Olsen (2016) who examined emerging trends in recently introduced BI courses. Students select large datasets (Anderson et al., 2014); extract, transform, and load (ETL) data into data models (Chiang, Goes, and Stohr, 2012); analyze the data, create dashboards, and consider the strategic use of BI applications (Gupta, Goul, and Dinter, 2015); and communicate their findings orally and in writing (Anderson et al., 2014). These course requirements align with the first two pillars of BI curriculum identified by Kang, Holden, and Yu (2015) which are (1) data preprocessing, storage, and retrieval and (2) data exploration. As this is an introductory course, algorithm and application development included in the second pillar are considered beyond the scope of the course.

The BI course in this study incorporates discussion, group work, and active learning. These student engagement techniques encourage students to act as co-creators of knowledge and help them develop a deeper understanding of DSA concepts. Based on the post-secondary discussion literature (Brookfield and Preskill, 2005), class teams are purposely formed as heterogeneous groups to promote a diversity of skills, opinions, and experiences; and class-wide reporting techniques are used. To examine the effectiveness of this course design, we investigate the following research questions:

RQ1: Does the use of discussion in a business intelligence classroom improve BI skills achievement?
RQ2: Does small-group team formation impact BI skills achievement?
RQ3: Does an active learning approach enhance BI skills achievement?

2.1 Discussion as a Pedagogical Approach

In the following sections, we discuss prior literature focused on Discussion and Active Learning techniques used in college level classrooms to improve student outcomes. The extant literature highlights the benefits of discussion in K-12 settings (Michaels, O'Connor, and Resnick, 2008), as well as in post-secondary institutions (Rocca, 2010). Studies have found a discussion-based classroom approach helps students learn new concepts, prepares them for independent learning (Mercer and Howe, 2012), and promotes an enriched understanding across class participants (Eeds and Wells, 1991). Discussion can prompt students to pause and reflect upon their learning. The literature has espoused that experiences in the classroom or workplace *must* be processed through subsequent reflection to fully maximize the inherent benefits (Lewis and Williams, 1994). Brookfield and Preskill (2005) offer 15 potential benefits of post-secondary classroom discussion. We find three of these ideas particularly salient for the BI classroom: helping students connect to a topic, affirming students as co-creators of knowledge, and enhancing collaborative learning (Brookfield and Preskill, 2005, pp. 28-34).

Despite its promise, the use of discussion over traditional pedagogical techniques may be rare (Mercer and Howe, 2012) with student-led discussion more likely to occur in communication courses than in other social or natural sciences (Crombie et al., 2003). Understanding how discussion enriches the learning experience is examined here in the context of business intelligence instruction. Discussion literature in post-secondary classrooms found mixed effectiveness, including the reluctance of some students to participate, with variance based on the nature of questions asked by faculty and the overall classroom environment (Dudley-Marling, 2013). The manner in which discussion is incorporated into the class will impact its effectiveness, as specific instructional methods impact the behavioral, affective, and cognitive aspects of student engagement (McKeachie et al., 1986; Syler and Baker, 2016). We use a comparative analysis to investigate the impact of introducing a series of engagement by design activities, including discussion, active learning, and group work to increase student learning.

2.2 Active Learning

Prince (2004) broadly defines active learning as any pedagogical technique that engages students in the overall learning process, in contrast to traditional lecture where students are passive recipients of information and knowledge. Active learning approaches can be divided into three related categories: collaborative learning, cooperative learning, and problem-based learning. Both collaborative and cooperative forms of active learning use structured groups to pursue common goals while incorporating mutual interdependence, face-to-face interaction, appropriate practice of interpersonal skills, and regular self-assessment of team functioning (Johnson, Johnson, and Smith, 1998; Prince, 2004; Strayer et al., 2019). Collaborative learning is characterized by classroom environments where learning is facilitated by social interactions rather than solitary endeavors and student work is evaluated in small groups. Cooperative learning also embraces group work and social interaction, but students are evaluated individually rather than by a group assignment with a common grade (Johnson, Johnson, and Smith, 1998; Prince, 2004). Problem-based learning introduces relevant problems to serve as a lens and provides motivation for the learning that ensues (Prince, 2004). Similarly, all three active learning techniques include activities performed in the classroom and include cooperative incentives to promote social learning rather than competitive and individualistic learning (Prince, 2004; Strayer et al., 2019).

Prior literature posits that increased student engagement is the link between active learning and improved student learning outcomes. Fundamental to active learning approaches are engagement-by-design activities that force behavioral engagement because students need to be actively engaged to learn. Solving problems helps students achieve higher-order thinking, and an open and relaxed environment reduces barriers to learning (Riordan, Hine, and Smith, 2017). Studies indicate teamwork, in both the collaborative and cooperative forms of active learning, enhance student motivation (Dadach, 2013) and increase student achievement as compared to individual work (Johnson and Johnson, 1989). Furthermore, students in high-collaboration teams are more satisfied than those in low-collaboration teams (Napier and Johnson, 2007). In the remaining sections of this paper we discuss: (1) the institutional context of the course, (2) how the course fits in the curriculum and the expected prior knowledge of students entering the course, (3) the software selected for the course, (4) the data challenge which is a comprehensive end-of-semester assignment, and (5) the four-semester process during which one engagement by design activity was added per semester to increase student learning. We then discuss our research model, measurement methodology, and results. We conclude by offering suggestions for BI course development and areas for further study.

3. BACKGROUND

3.1 Institutional Context

The institutional context of the course is a recently established, public, undergraduate-only institution located near a major metropolitan area. The institution has experienced rapid enrollment growth since its inception. Its access admissions policy, affordable tuition, and excellent reputation within the region have supported its rapid growth and made it attractive to a highly diverse student population. Excellence in teaching, an emphasis on student success, and continuous improvement in innovative classroom instruction are hallmarks of the institution.

Within the institution, there is an AACSB-accredited School of Business Administration (SBA) that offers a Bachelor of Business Administration degree (BBA) with concentrations in management, finance, accounting, supply chain management, economics, management information systems (MIS), marketing, and international business. As of Fall 2018, approximately 2,700 students were enrolled in the BBA program with approximately 250 of them in MIS. Completion of the BBA requires 123 hours of instruction, divided into 66 semester credit hours of general education, 36 hours of required business core credits, and 21 hours of concentration/elective courses. Within the business core are an introductory course in MIS with intermediate level Excel, two statistical analysis courses, and one management science course. Students concentrating in MIS are also required to complete courses in programming (Python or Java), database (Oracle, Visio, and SQL), systems analysis and design, and systems implementation (C#). Additionally, MIS students are encouraged to pursue a minor in information technology and/or complete an internship to further develop their technical skillset. By their junior/senior year, MIS students have typically developed a significantly more extensive technology skillset than those in other concentrations.

3.2 Course Overview

The MIS curriculum is reviewed annually to ensure students receive the most relevant, market-driven course content using feedback from multiple stakeholders. One result of this review is the recent replacement of a telecommunications course covering network protocols, wireless networks, and security with a BI course, as faculty recognized the increasing importance of data-driven decision making (Agarwal and Dhar, 2014). The new BI course was developed to focus on the increasing amount of complex data being stored worldwide and was intended to teach students the skills required to analyze data and convert data into actionable knowledge to improve business outcomes. The BI course is designed to be accessible to all business majors in need of an elective, but it is required for MIS concentrators.

The BI course combines conceptual knowledge lectures on data management from a managerial perspective, followed by active learning assignments using hands-on software tools. Course topics include big data, technology changes enabling BI, reports and visual analytics including infographics, data warehousing, BI front-end tools, and data quality. The topics covered are consistent with the suggested four pillars of analytics curriculum: 1) data preprocessing, storage, and retrieval; 2) data exploration; 3) analytical models and algorithms; and 4) data product (Kang, Holden, and Yu, 2015). The student learning outcomes are directly related to the first two of these pillars and are:

1. Understand the business uses and value of business intelligence
2. Explain data integration and the extraction, transformation, and loading (ETL) process *[Pillar 1 Data Preprocessing, Storage, and Retrieval]*

3. Know different types of data visualization techniques and use business intelligence tools to create effective business reports *[Pillar 2 Data Exploration]*

4. Explain what big data is, discuss how it differs from data warehousing, and identify enabling technologies *[Pillar 1 Data Preprocessing, Storage, and Retrieval]*

5. Demonstrate beginning-level proficiency using applications to analyze data using BI and analytics software *[Pillar 2 Data Exploration]*

The BI course gradually builds each student's knowledge of BI concepts and tools using the pedagogical techniques described in the literature as effective for student learning. It uses an active learning model (Stefanou et al., 2012; Riordan, Hine, and Smith, 2017; Strayer et al., 2019) throughout 16 weeks of instruction (8 in summer). During the first two-thirds of the course, students build foundational knowledge and become increasingly proficient with BI tools including Power View, Smart PLS, and table joins. Students have graded assignments both inside and outside of class to incentivize practice and improve skill level. These exercises typically use real-world data downloaded from government websites or teaching cases with an authentic business context (Napier, 2018). During the latter part of the semester, students apply what they have learned on an individual or team-based final project known as the Data Challenge (described more fully in Section 3.4 below).

3.3 BI Software Selection

The course software selection process required faculty to consider software capability, ease of use, availability, and cost. Based on the business school core curriculum, all students gain intermediate level MS Excel skills, but only MIS concentration students typically have experience with programming and database tools. These considerations led to the selection of Microsoft Power BI add-ins for Excel (Power Pivot and Power View) and Smart PLS as the primary BI software tools. Power Pivot allows users to create data models within Excel, analyze data imported from a variety of data sources, and, like MS Access, build table relationships. It supports large datasets and has an intuitive interface that is reminiscent of Access for those familiar with databases, but it is non-intimidating for those who are not. Figure 1 provides an illustration of a table join using Power Pivot.
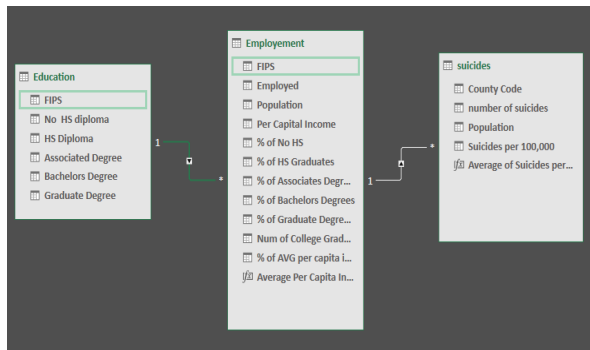

Figure 1. Power Pivot Table Join

Power View adds basic dashboard capabilities to create multiple visualizations within Excel. Figure 2 provides an

illustration of a dashboard using Power View. Microsoft Power BI tools combine much of the functionality of Access in Power Pivot and enhance data presentation capabilities with Power View. Microsoft Power BI is included at no additional cost in Microsoft Excel (beginning with the release of Excel 2016) and allows students to build on their existing knowledge of spreadsheet software.
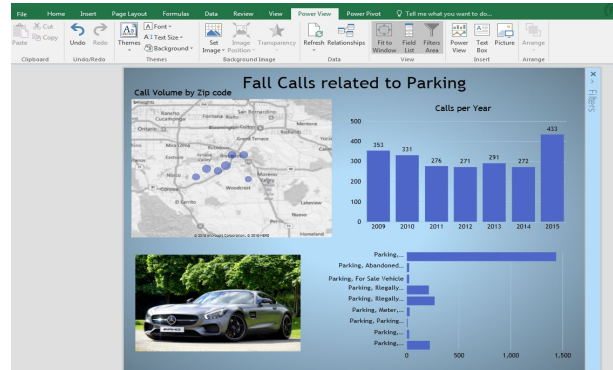

Figure 2. Power View Dashboard

While data models, graphs, charts, and dashboard visualizations are useful DSA tools, the faculty also decided to include a regression tool to support more robust analytics. SAS and SPSS were considered, but not chosen because corporate licenses can be expensive and, consequently, these may not be readily accessible to students after graduation. R was also considered as it is powerful analytical software and is free; however, the user interface can be challenging for students with a limited technical skillset. Instead, Smart PLS 2.0 was chosen since the license for version 2.0 is free, and the interface and output are visual and easy to use. Figure 3 includes a sample Smart PLS screenshot of the project and workspace view where a path model is constructed.
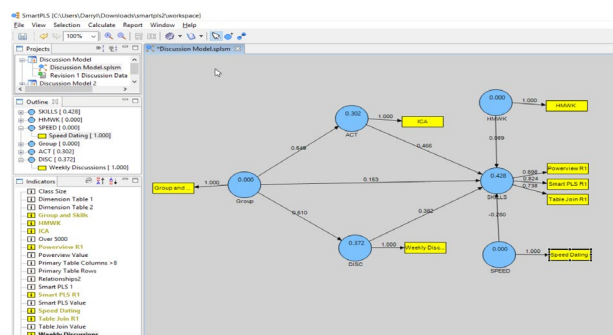

Figure 3. Smart PLS

Selection of the Smart PLS 2.0 software tool provides students with hands-on instruction with powerful analytics tools that graduating students can continue to use without the need for corporate sponsorship. Together, Power Pivot, Power View, and Smart PLS are a robust set of tools for students to use for DSA instruction and when they enter the workplace.

3.4 Data Challenge Comprehensive Course Assessment

After having gained proficiency using the BI tools described previously, students turn their attention to the Data Challenge

which serves as a final assessment for the course and takes the place of a final exam. This assignment requires students to serve as "citizen data scientists" (Gartner, 2017, January 16) by using real-world, publicly available data to answer research questions, investigate problems, and explore relationships. The project is, by design, cooperative learning (Stefanou et al., 2012; Riordan, Hine, and Smith, 2017) with students producing an individual component before working with a partner on the final deliverables.

3.4.1 Individual component. During the individual component, students are required to develop research questions of interest and find two or more relevant datasets to use to explore those research questions. They may not use datasets previously introduced by the instructor and are encouraged to use primary datasets with at least 5,000 rows and 6-8 columns. Often, students select datasets with millions of rows and several thousand fields. Examples of student research questions and data sources are:

- Does an institution's average SAT score, federal financial aid award, and average family income predict alumni salaries 10 years after starting a college degree? Data sources: U.S. Department of Education and U.S. Office of Federal Student Aid
- How does the poverty rate affect the number of registered sex offenders or teen birth rates? Data sources: Sex Offender Registry and Data USA

Following data selection, students create a data dictionary, specifying metadata for each table used (i.e., column name, data type, valid data, brief description). Students use the technical skills learned earlier in the course to import their data into Excel Power Pivot, create table joins, and extend the data model through data transformations. Using the resulting data model, students create pivot tables that demonstrate proficiency in sorting, conditional formatting, and filtering.

3.4.2 Team final deliverable. The second part of the data challenge requires pairs of students to combine the work done independently into a single Excel file using table joins. Once the data model is updated, the students work as a team to create a Power View dashboard, then load and run Smart PLS regressions using their combined variables to empirically answer their research questions and test for significance. During the final week of class, students present their project findings to their peers, solicit feedback, and prepare a final summary report. Occasionally, students chose to complete the final submission alone, which is allowed, but not encouraged. Table 1 provides a summary of the assignment requirements.

Outcome	Description
Individual Component	• Select a dataset not used during class as your primary fact table. • Join a second table to elaborate on one dimension of this fact table. • Create a data dictionary describing the metadata for both tables. • Using the resulting data model, create several pivot table reports.
Team Final Deliverable	• Combine work with a partner into a single Excel file and add an additional dimension tab. • Create a Power View dashboard. • Generate a summary report in Word or with an infographic. • Run Smart PLS regression on the project and test for significance

Table 1. Data Challenge Assignment Requirements

3.5 Four-Semester Progressive Course Design
This study examines the efficacy of progressively introduced course design components used during four consecutive semesters. Across the four semesters, the student learning outcomes, BI tools, and Data Challenge project requirements remain consistent. However, each semester the course was taught, the instructor added a significant "engagement by design" element based on student feedback and the instructor's desire to improve student learning. Over the four semesters, the course design varied in four key ways: introduction of required discussion, formation of semester-long teams, increase in-class assignments, and use of speed dating. A summary is included in Table 2 and each variation is described below.

Semester	1	2	3	4
Full-Class Discussion	No	Yes	Yes	Yes
Team Formation	No	No	Yes	Yes
Speed Dating	No	No	No	Yes
Students Enrolled	35	12	28	33
In-Class Assignments	14	14	17	20

Table 2. Peer-to-Peer Interaction Techniques Utilized

3.5.1 Semester 1 – Baseline. During Semester 1, the instructor taught the BI course without specific techniques to promote peer-to-peer interaction and discussion. In-class exercises were typically individually performed and assessed, and students sat in the location of their choice throughout the term. Although students were encouraged to help one another, there were no incentives to do so. The instructor was the primary source of help, assisting students individually throughout the class session leading to the following three observations:

1. With a class size of 35, a personalized approach meant that a limited number of students received individual assistance in each class. While the most vocal students attracted the attention of the instructor, not all students received their desired level of assistance.

2. Since students selected their own seats, they often sat next to their friends whose technology capabilities most resembled their own. When these students had limited prior exposure to technology, they did not have the ability to help each other.

3. To ensure adequate class time to present their data challenge projects, students were strongly encouraged to find a partner. Finding a suitable partner with complementary research questions and datasets proved difficult, especially when they chose a partner based on proximity. For instance, two students paired to study the impact of weather on crime statistics; their tables did not have related columns to join, and, not surprisingly, their results found spurious correlations.

3.5.2 Semester 2 – Adding full-class discussion. During Semester 2, a smaller class size of 12 allowed the instructor to adopt more of a seminar style in the classroom. Inspired by the concurrent reading of *Discussion as a Way of Teaching* by Brookfield and Preskill (2005), the instructor added intentional class discussions requiring each student to reflect on their learning, often while sitting conference table-style. Students were asked broad, open-ended questions about the course, such as "What did we discuss last week?" Other times, students were asked more focused questions about specific assignments, such as "What did you learn from the assignment that stuck out to you" or "What did you have trouble with?" With the smaller class size, the group facilitated active learning and discussion.

While working on the Data Challenge, students openly discussed their projects and solicited help from others when needed. Students shared their experiences, described their successful identification of suitable datasets from widely available sources such as data.gov, showed others how they transformed their data to enable table joins, and solicited help with research questions well suited to their datasets. Students actively engaged with their group members, classmates, and instructor to consistently improve their evolving projects.

The opportunity to engage in open discussion was beneficial for the students. The quality of their deliverables improved, they developed communication skills using BI jargon, and they created a supportive classroom environment. By sharing issues, students realized they were not alone in their struggles. Discussion provided an opportunity for students to assist other students while reinforcing their own learning.

3.5.3 Semester 3 – Adding team formation. During Semester 3, the class size more than doubled as compared to the previous semester when discussion was first introduced. To scale this pedagogical improvement, the instructor used Brookfield and Preskill's (2005, p. 101) creative grouping technique to introduce semester-long teams within the class. They recommend a group size of five for optimal interaction, that groups be comprised of students with varying opinions and experiences, and that groups discuss concepts covered in the class at least once weekly within the group then share their ideas with the entire class (Bruffee, 1993; Brookfield and Preskill,

2005). Students were assigned to four-five person teams based on each student's incoming technology skillset. During the initial class, students self-reported their knowledge of Power Pivot, Power View, infographic creation, table joins, SQL, and Access. Each team had a mix of students self-reporting high and low technology skillsets. Team discussion was encouraged during class time, and groups shared their ideas with the larger class. For instance, in one class session, students were asked to discuss important options on the Excel Power Pivot ribbon and were asked in a later session to discuss the conditions required for a valid table join using the Create Relationships tab.

Using creative grouping, the benefits of class discussion continued even though the class size increased. Students were asked to discuss concepts and issues within their team for several minutes, then engage in a broader discussion that involved the entire class. Peer-to-peer interaction increased, and, since the small groups were comprised of students with heterogeneous (high and low) incoming technology skills and prior BI experiences, team members were often able to assist each other. As students were engaged socially through discussion, they were willing to provide the needed assistance. Consequently, the instructor spent less time individually assisting students, covered additional material, and introduced three new in-class assignments (see Table 2 above). However, during the Data Challenge portion of the class, students often relied on others within their group when looking for partners and identifying research questions, even when their datasets were not necessarily well-suited for this purpose.

3.5.4 Semester 4 – Adding speed dating. During the fourth semester, the instructor continued the active learning and discussion pedagogical techniques within assigned skills-based teams. This approach supported three additional in-class exercises that focused on table joins, Smart PLS analysis, and interpretation. To help students find partners for the Data Challenge, a 20-minute speed dating exercise was added. Students often completed their final projects with a partner from their existing group even if a more suitable partnership existed outside of their original five-member teams. Through a series of four rotations (five minutes each), students shared their research questions, datasets, and table join keys with their classmates. For each rotation, students discussed their research interests with a new group of classmates with the intent of finding a suitable partner for their final project and presentation. An ideal partner would share research interests (e.g., sports, social justice, healthcare, etc.) as well as compatible datasets. The introduction of speed dating improved the quality of many student's data challenge project deliverables.

4. RESEARCH MODEL

The introduction of engagement by design elements (Riordan, Hine, and Smith, 2017) across four consecutive semesters creates a natural experimental design from which we investigate the impact of structured group formation (GRP); active learning, in-class exercises (ACT); and in-class discussion (DISC) on student learning. Homework (HMWK) and speed dating (SPEED) are included as control variables. Figure 4 is an illustration of the research model. The research model constructs are defined in Table 3, with a summary of the measures used and the prior literature informing the construct.
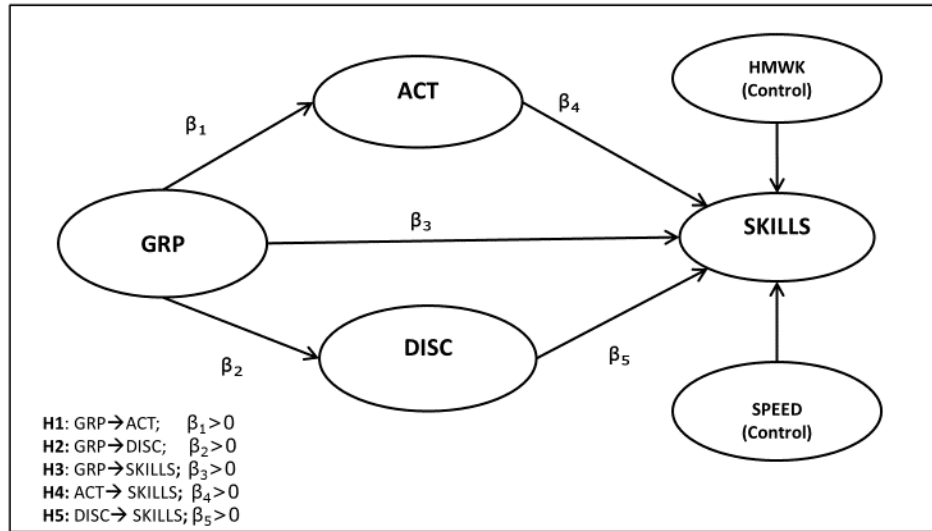
Figure 4. Research Model

Construct	Acronym	Measures	Informing Sources
Team formation	GRP	• Group formation based on student self-report incoming skills assessment • Binary score of 0 or 1	Small group, active learning literature (Smith and MacGregor, 1992; Millis and Cottell, 1997; Brookfield and Preskill, 2005; Conduit et al., 2017)
Active Learning In-Class Assignments	ACT	• The number of cooperative and/or collaborative in-class exercises completed by each student over the term • Number of assignments	Active learning (Prince, 2004; Riordan, Hine, and Smith, 2017; Strayer et al., 2019)
Discussion	DISC	• Weekly group followed by class-wide discussion reflecting on student difficulties and triumphs using the technologies for ICA's and specific data challenge tasks • Binary score of 0 or 1	Discussion as an effective technique to improve student learning (Brookfield and Preskill, 2005; Dudley-Marling, 2013)
Homework Assignments	HMWK	• The number of homework assignments • Number of assignments	Traditional pedagogical approach
BI Skills	SKILLS	• Composite of three BI skills 1) Demonstration of two or more table joins 2) Demonstration of four or more integrated dashboard visualizations 3) Demonstration of BI analytics through a SEM regression with significance • Score of 0-3	Business intelligence pillars of analytics learning categories (Kang, Holden, and Yu, 2015; Mills, Chudoba, and Olsen, 2016).
Speed Dating	SPEED	• Included in semester 4 to help students form Data Challenge partnerships • Binary score of 0 or 1	Introduced by instructor

Table 3. Active Learning Model Constructs

4.1 Model Measurements

4.1.1 Dependent variable. BI Skills (SKILLS) is the dependent variable and is operationalized by assessing three distinct technical capabilities illustrated in the end-of-term data challenge project. Each capability is successively evaluated with points added to the score based on the quality of the submission. The lowest possible composite score is 0 and the highest is 3. The composite score is used as the SKILLS dependent variable data point. The three capabilities are:

- Capability 1: Demonstration of two or more operational table joins;
- Capability 2: A Power View dashboard with four (or more) visualizations; and,
- Capability 3: Use of Smart PLS structural equation modeling to demonstrate significant associations between constructs.

The first capability requires students to use Power Pivot to join tables using one primary and two secondary tables. To measure this capability, we rate each submission a 0, 0.5, or 1. An example of a successful table join is provided in Figure 1. If a table join is not evident in the diagram view, the key fields are of differing data types, or the fields used in the table join are unrelated, then this skill is rated as 0. If there is one successful table join, the skill is rated a 0.5. Two (or more) successful table joins are rated a 1.0.

To create the table joins, students are often required to transform their data using field concatenations, calculated fields, and/or many-to-one relationships between primary and secondary tables. Capability 1 focuses on the student's ability to complete the preprocessing stage of their project, including data extraction and transformation. This skill is consistent with Pillar 1 of the business intelligence curriculum category Preprocessing, Storage Retrieval, and Data Modeling (Kang, Holden, and Yu, 2015).

Capability 2 is evaluated by examining the pivot tables, pivot charts, and Power View dashboards generated by the students. When properly constructed, the Power View dashboard produces an interactive and visually appealing depiction of the data and allows the user to convey a story. When related pictures are combined with data driven visualizations in the form of pie charts, graphs, and maps, the dashboard becomes an interactive infographic. Inclusion of a Power View dashboard (example in Figure 2) adds 0.5 to the SKILLS composite score. Power View also includes functionality to dramatically improve the appearance of the dashboard beyond the base output. We add 0.25 for visual appeal if the background is changed from the standard white, text boxes are added, varied fonts are used to highlight chart titles, and/or topic-related pictures are added. Finally, the students are instructed to include at least four or more visualizations on the dashboard. We add 0.25 to the score for four or more visualizations. This capability aligns with Pillar 2 Data Exploration (Kang, Holden, and Yu, 2015).

Capability 3 is evaluated by examining the student's Smart PLS regression output included in their presentation and/or final Data Challenge report. Inclusion of Smart PLS regression analysis adds 0.5 to the composite SKILLS score. Additionally, we evaluate the plausibility of the overall conceptual model. A

thoughtful choice of variables earns an additional 0.25. Associations likely to be spurious, such as the impact of NFL passer ratings on overall city crime rates, would not earn any additional points. Finally, since students are encouraged to acquire large datasets to demonstrate their BI skills and increase the likelihood of significant results when testing associations between constructs, we added an additional 0.25 to the SKILLS score when Smart PLS regressions are significant. Capability 3 is also consistent with Pillar 2 of the Kang, Holden, and Yu (2015) Four Pillars of Analytics.

4.1.2 Independent variables and controls. For our independent variables, we begin with the pedagogical approaches of using structured group formation and purposeful discussion techniques, which are captured as GRP and DISC. These are operationalized in binary form (0 or 1) as they were introduced according to Table 2. The active learning construct (ACT) is captured as the number of individual-level collaborative or cooperative classroom assignments that each student completed over the term. As highlighted in Table 2, the number of available assignments increased from 14 to 20 over the 4 sections as new assignments, particularly related to Smart PLS and the data challenge, were added. Finally, as a control variable, we added the number of homework assignments completed (HMWK) and "Speed Dating" as a technique to facilitate the process of finding a suitable partner to combine projects for the end of term presentation and final submission.

4.2 Analysis
We used Partial Least Squares (PLS) regression and the Smart PLS 2.0 software (Ringle, Wende, and Will, 2005) to analyze our data. Smart PLS is suitable for exploratory models which incorporate newly formed constructs, such as our dependent variable (SKILLS) (Gefen, Rigdon, and Straub, 2011). Also, compared to covariance-based Structural Equation Modeling (SEM) techniques that rely on reflective measurement items captured through survey data, Smart PLS can estimate models using multiple indicators derived from archival data such as ours. Third, Smart PLS has fewer distributional assumptions as compared to covariance-based SEM (Gefen, Rigdon, and Straub, 2011).

5. RESULTS

To test our research model, we conducted a PLS analysis with 1,000 bootstrap samples. The standardized path coefficients, standard errors, and significance of the paths are reported in Figure 5 and Table 4. Our model does not include a control variable for instructor-only because all sessions of the class are taught by a single instructor. As a robustness test, we ran regressions with class size included as a control on the interventions and found only nominal changes in the focal path coefficients, their standard errors, and the overall variance explained. The number of homework assignments (HMWK) is used as a control variable, which proved to have a non-significant effect on overall SKILLS attainment HMWK > SKILLS = 0.089 (0.473) NS. The speed dating exercise (SPEED) is also a control variable. This structured exercise requires each student to share details about their individual datasets to help them form partnerships with other students who have complementary datasets and research questions. Findings
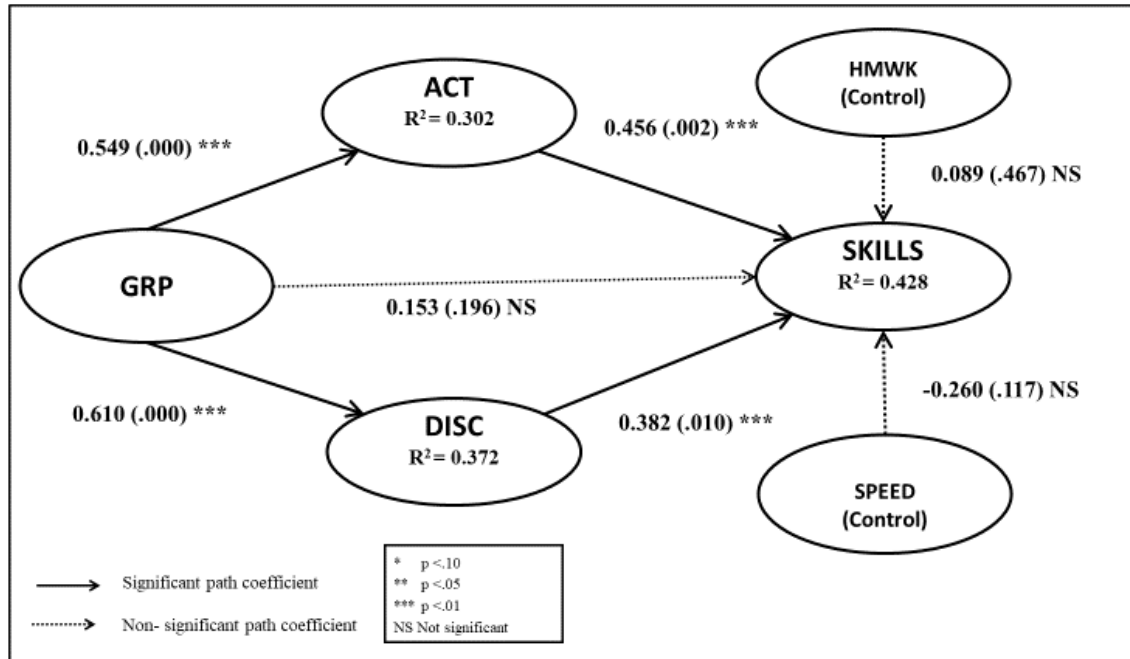
Figure 5. Structural Model Estimation Results

Main Effects			T Value	Results	Research Question	Hypothesis Confirmed
β1: GRP	→	ACT	9.76	0.549 (0.00) ***		
β2: GRP	→	DISC	11.13	0.610 (0.000) ***		
β3: GRP	→	SKILLS	1.23	0.153 (0.196) NS	RQ2	No
β4: ACT	→	SKILLS	3.09	0.456 (0.002) ***	RQ3	Yes
β5: DISC	→	SKILLS	2.53	0.382 (0.010) ***	RQ1	Yes
DISC R^2				0.372		
ACT R^2				0.302		
SKILLS R^2				0.428		
Controls			T Value	Results		
HMWK	→	SKILLS	0.73	0.089 (0.467) NS		
SPEED	→	SKILLS	1.57	-0.260 (0.117) NS		

Table 4. Structural Model Estimation Results

indicate a negative association between the introduction of the speed dating exercise (SPEED) and skills attainment (SKILLS) SPEED>SKILLS = -0.260 (0.117) NS that was not significant at the 0.10 level. Although the results were not significant, the negative path coefficient warrants further evaluation. One possible explanation for the negative coefficient result is that students with robust datasets chose to pair with each other, leaving students with potentially weaker datasets without a strong partner option.

From the structural model results, we find that Group formation (GRP) is positively associated with the number of collaborative and cooperative in-class assignments completed by each student over the term (ACT) ($\beta 1 = 0.549$, $p < 0.01$). Formation of groups using an incoming skills self-assessment increased the ability of the instructor to cover more material and require additional in-class assignments. This increased BI skills exposure to the entire class cohort. Results also indicate group formation enables the *introduction* of discussion-based pedagogical techniques, as GRP is also positively associated with class discussion DISC ($\beta 2 = 0.372$, $p < 0.01$). It is important to note that variance in the levels of student discussion was not empirically captured; this measure indicates that discussion-based activities were introduced as a pedagogical approach. Lastly, our results indicate, interestingly, that group formation (GRP) does not have a strong, direct effect on overall skills attainment (SKILLS) ($\beta 3 = 0.153$, $p < 0.20$) and is not significant.

From our structural model results, we find that higher levels of ACT are positively associated with our dependent variable skills attainment (SKILLS) ($\beta 4 = 0.456$, $p < 0.01$). Each in-class assignment reinforced skills covered earlier in the term and introduced the students to new skills introduced that day through lecture and demonstration. The intent of each in-class assignment was to prepare students for two individual exams (40% of grade) as well as to foster ideas for their data challenge projects. We find that the strongest predictor of SKILLS is the cooperative and/or collaborative completion of in-class assignments (ACT). Our results also indicate that the introduction of purposeful, discussion-based pedagogical techniques (DISC) is positively associated with skills attainment (SKILLS) ($\beta 4 = 0.382$, $p < 0.01$).

Results also suggest the positive effects of forming classroom groups (GRP) to increase student engagement and overall skills attainment (SKILLS) is mediated by discussion (DISC) and active learning (ACT) techniques that force engagement by design. To test the mediation effects of GRP on SKILLS through ACT, we conduct a product-of-coefficients test using bootstrapping to estimate the standard error (Preacher, Rucker, and Hayes, 2007). This approach does not require distributional assumptions inherent to earlier techniques, such as the Sobel test (Baron and Kenny, 1986). We compute the indirect effect ($z' = \beta 1 \times \beta 3$, with $\beta 1$ being the effect of GRP on ACT and $\beta 3$ being the effect of ACT on SKILLS) and its standard error (σ). The mediation effect is significant ($\sigma = 0.088$, $z' = 0.267$, $p < 0.01$), thus supporting the conclusion that the impact of the introduction of skills-based groups (GRP) on skills attainment (SKILLS) is fully mediated through active learning (ACT).

To test the mediation of GRP on SKILLS through DISC, we use a product-of-coefficients test using bootstrapping to estimate the standard error as prescribed by Preacher, Rucker,

and Hayes (2007). We compute the indirect effect ($z' = \beta 2 \times \beta 4$, with $\beta 2$ being the effect of GRP on DISC and $\beta 4$ being the effect of DISC on SKILLS and its standard error (σ). Again, the mediation effect is significant ($\sigma = 0.092$, $z' = 0.237$, $p < 0.01$) indicating that the impact of the introduction of skills-based groups (GRP) on skills attainment (SKILLS) is fully mediated through the introduction of purposeful discussion (DISC) techniques in the classroom.

The results of our structural model estimates are related to our original research questions and expected outcomes in Table 4 above. Results of the analysis for the first research question, "Does the use of discussion in a BI classroom improve BI skills achievement," suggest strong positive support for the use of discussion-based pedagogical techniques (significant at the $p < 0.01$ level). Interestingly, our analysis for the second research question "Does small-group team formation impact BI skills achievement?" indicates that group formation does not have a significant direct effect on BI skills. This empirical outcome was unexpected as team formation seemed to have an overwhelmingly positive effect on skills achievement. Only when we tested the mediated effect of $\beta 1$ group formation (GRP) on ACT, and the mediated effect of $\beta 2$ group formation (GRP) on DISC, did we fully understand the important influence of purposeful team formation. Finally, for our third research question "Does an active learning approach enhance BI skills achievement," we found that active learning pedagogical approaches do have a positive effect on BI skills (significant at the $p < 0.01$ level).

6. DISCUSSION

We suggest that business analytics pedagogy differs from teaching other IS topics as students must learn to become data-driven decision-makers (Jeyaraj, 2019) who will work in increasingly collaborative organizational environments. Wixom et al. (2014) found that the top skill desired by employers when making BI/BA hiring decisions is task driven communication. Our context has highly contingent inputs and outputs, unlike a traditional programming course with prescribed outcomes. Our students have diverse backgrounds and varying prior instruction on IT skills, and our context is an access institution, which accentuates the impact of a skills-based, self-assessment for early-term group formation. The Data Challenge is a student-led project with students selecting their own research questions and data sources, choosing primarily among the more than 200,000 government datasets at Data.gov. While students are given specific guidelines and objectives to complete the project, the permutations and combinations of data, research questions, visualizations, and data models with acceptable outcomes are infinite. We suggest that for up to 40 students, and one instructor, to navigate the complexities of table joins and significance tests on datasets of their choice, requires an open discussion and active learning environment where students learn to collaborate and effectively incorporate suggestions and the experience of others. The following section discusses the lessons learned during this research project.

6.1 Lessons Learned
When active learning and discussion techniques are coupled with a small-group, skills-based team formation process, we find an empirically positive result on overall BI skills

attainment. In this section, we offer instructors four lessons learned on improving student learning of BI skills.

6.1.1 Lesson 1. *Incorporate more in-class assignments throughout the term to support new skills and concepts introduced through lecture.* Prior research has found that cooperative and collaborative class work can improve student achievement (Johnson and Johnson, 1989). Consistent with this, we found active learning pedagogical approaches have a positive effect on BI skills. Over the four-semester period studied, more in-class assignments were added, increasing from 14 assignments to 20. The new assignments provided additional practice with Power Pivot and reinforced Smart PLS skills. Not surprisingly, the more in-class assignments students completed successfully, the better they performed on the end-of-semester data challenge project. This factor was the strongest predictor of success.

Requiring students to be in the classroom to complete this work had some additional benefits compared to assigning practice as homework: students had the opportunity to support their group members and were more likely to engage in the social aspects of the learning process. To incentivize attendance, absent students were not allowed to submit from home and received a 0 for missed in-class assignments. Anecdotally, over the semester, students would start to leave their seats to help other teammates sitting four chairs away, as well as classmates from other teams, if their existing teammates had already completed their assignment. While in class, most students eventually shared the correct syntax with their team to earn a 100 on their assignments. These behaviors were rare at the outset of the semester, but they became more frequent as the semester continued.

6.1.2 Lesson 2. *Form purposeful groups at the beginning of the term to encourage peer-to-peer interaction and student problem-solving.* Prior to forming teams in class, the instructor was the primary source of assistance when students had a question. Despite best intentions, we found an inverse relationship between the frequency of instructor provided help during lecture / in-class assignments and end-of-term skills attainment. It appeared that once the instructor solved the problem, the student soon forgot how the problem was solved. In addition, as class sizes increased, waiting on the instructor to fix a problem became a bottleneck. By contrast, with purposeful team formation and an active learning approach, the cohort relied on input and support from each team member rather than just relying on the instructor.

We found creative grouping particularly useful and followed two key principles of Brookfield and Preskill (2005): 1) form heterogeneous groups to promote a diversity of skills, experiences, and opinions and 2) keep group size optimally at five students. Surveying students based on their incoming technical skills led to the formation of teams of varying individual capabilities. This ensured each team had one or two individuals who were capable of assisting others with in-class assignments. Starting in semester three, skills-based teams were formed in groups of five students wherever possible. Beginning in semester four, the instructor also evaluated how students interacted during the first in-class assignment while still sitting in their chosen seats. The intent was to evaluate whether or not highly self-rated students would also be amenable to helping

others in their vicinity. This was important as the most capable students were often inclined to finish early and then ask to be excused from class early to attend to pressing matters that materialized outside of the class.

6.1.3 Lesson 3. *Add post-assignment discussion to prompt student reflection and reinforce learning.* Our results confirm the literature which suggests that discussion helps students connect to a given topic while reinforcing collaborative learning (Brookfield and Preskill, 2005). Over a number of classes, discussion was utilized to emphasize the conditions where a successful table join occurred. More importantly, on occasions where a student had difficulties with an unsuccessful table join during an in-class assignment, the instructor would subsequently cold-call the student to relay to the class how the specific difficulty was overcome, as prescribed by the literature (Brookfield and Preskill, 2005). Our results suggest that the incorporation of collaborative groups *and* reflective discussion were mutually reinforcing, as evidenced by overall skills attainment across the four sections.

Discussion takes up valuable classroom time, and when it is free flowing and student led, it can be difficult to determine the efficacy of the approach (Brookfield and Preskill, 2005). It is often easier to simply use the time to teach a new skill through lecture, and subsequently apply the skill through a traditional, collaborative, or cooperative approach as this structure is tangible. Our approach forces a pause and the time to reflect on what has been learned, the significance of the learning, and how the skill can be used upon graduation. By first sharing in small groups when a significant learning moment occurred for themselves, students are able to reflect and articulate their revelation prior to sharing it with the overall class. Many other students may not have reached the particular issue as they serendipitously completed the task correctly, leaving them unprepared to deal with the issue later in the term. The allocation of time to post-assignment discussion reinforces the notion of students as co-creators of knowledge and encourages a broader connection to the key course concepts (Brookfield and Preskill, 2005).

To promote open and democratic discussion, it is important to create a relaxed atmosphere from the outset of each term (Brookfield and Preskill, 2005). To that end, in the first class, all students were asked to get to know a partner next to them, ask them aspects of their academic background, and to obtain one interesting fact about their partner that many others may not know about themselves. Each partner then presented their findings on their partner to the class. As many of our students are non-traditional, working adults, this sharing of backgrounds proved enlightening as they learned of others the similarities and differences that they were previously unaware of, enabling a more relaxed and inclusive class atmosphere moving forward.

6.1.4 Lesson 4. *Utilize a culminating assignment, like the Data Challenge, that requires students to apply skills learned in a new context.* Most of the in-class assignments focused on practicing a narrow set of skills. Students were given clean data and asked to perform specific tasks leading to an expected answer. In many cases, the goal was simply to gain familiarity with using the applicable software tool. With the Data Challenge project, students are exposed to the messiness of real-world data. They are forced to ask their own questions of interest, find relevant datasets, decide which of the skills they

have learned are applicable, and even investigate new techniques as needed. A project requiring students to assimilate their skills is a valuable part of the class.

6.2 Limitations and Future Research
While there are limitations of this study, there are also opportunities for future research. First, our sample was limited to 100 students at a single school of business with the class size varying from 12 to 35 students over 4 successive semesters. Future research could investigate our findings within and across differing institutional contexts and with larger class sizes. Second, we found that active learning pedagogical approaches have a positive effect on BI skills. We measured active learning in terms of the number of collaborative and cooperative assignments completed. Future research can investigate the relative effectiveness of other forms of active learning such as the flipped classroom (Abeysekera and Dawson, 2015; McCollum et al., 2017; Talbert, 2017) augmented by learning logs (Babcock, 2007; Grimm, 2015). Third, we acknowledge that variances in the level of reflective classroom discussion are difficult to accurately measure. We do not attempt to explain variance in classroom discussion, only that purposeful discussion was introduced and its impact on skills was empirically measured. Future research may include a structured measurement of student engagement during reflective discussion on BI related topics. Fourth, we found that group formation is positively associated with work completed by students over the term. In our study, groups were assigned based on a skills-based self-assessment. Given the importance of teamwork, future research could investigate alternative group formation options according to the literature (Michaelsen, Knight, and Fink, 2002). Finally, our study measured skills attainment through the Data Challenge, a primarily Excel-based project with both individual and team components. Future research could consider other ways to objectively define and measure BI skills attainment of individual students.

<div align="center">

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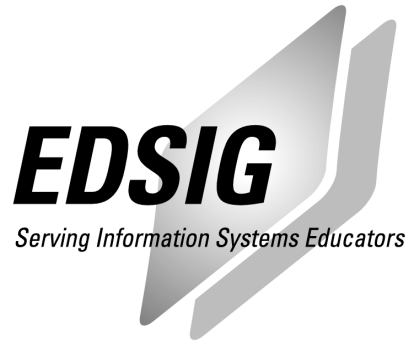
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