Journal of the Midwest Association for Information Systems

Table of Contents

Remembering Daniel Joseph Power
February 9, 1950 – January 26th, 2021
By Gaurav Bansal, Mari Buche, Omar El-Gayar, Joey George, Matt Germonprez, Yi "Maggie" Guo, Rassule Hadidi, Deepak Khazanchi, Barbara Klein, Shana Ponelis, Kevin Scheibe, Shu Schiller, and Troy Strader

A Practitioner Methodology for Mitigating Electronic Data Risk Associated with Human Error
By Dennis C. Acuña, Rajab Suliman, and Nasir Elmesmari

Using Prototyping to Teach the Design Thinking in an Asynchronous Online Course
By Mary C. Lebens

Volume 2021, Issue 2, July 2021

www.JMWAIS.org

Contact

Joey F. George
The John D. DeVries Endowed Chair in Business
ISU Distinguished Professor in Business
Debbie and Jerry Ivy College of Business
Iowa State University
Ames, IA 50011
(515)294-7162
jfgeorge@iastate.edu

Rassule Hadidi, Dean
College of Management
Metropolitan State University
Minneapolis, MN 55403-1897
(612)659-7295
rassule.hadidi@metrostate.edu

Journal of the Midwest Association for Information Systems (JMWAIS) at http://jmwais.org is a double-blind, peer-reviewed, quality focused, and open-access online journal published by the Midwest United States Association for Information Systems at http://www.mwais.org/. The infrastructure for online publication of this journal is currently provided by the Metropolitan State University, St. Paul, Minnesota.

Journal of the Midwest Association for Information Systems

Table of Contents

Articles **Page**

Remembering Daniel Joseph Power
February 9, 1950 – January 26th, 2021 **1**
By Gaurav Bansal, Mari Buche, Omar El-Gayar, Joey George, Matt Germonprez, Yi "Maggie" Guo, Rassule Hadidi, Deepak Khazanchi, Barbara Klein, Shana Ponelis, Kevin Scheibe, Shu Schiller, and Troy Strader

A Practitioner Methodology for Mitigating Electronic Data Risk Associated with Human Error **9**
By Dennis C. Acuña, Rajab Suliman, and Nasir Elmesmari

Using Prototyping to Teach the Design Thinking in an Asynchronous Online Course **27**
By Mary C. Lebens

Editorial Board

Journal of the Midwest Association for Information Systems

Volume 2021 | Issue 2 Article 1

Date: 07-31-2021

Remembering Daniel Joseph Power

February 9, 1950 – January 26th, 2021

Gaurav Bansal, Mari Buche, Omar El-Gayar, Joey George, Matt Germonprez, Yi "Maggie" Guo, Rassule Hadidi, Deepak Khazanchi, Barbara Klein, Shana Ponelis, Kevin Scheibe, Shu Schiller, and Troy Strader

Abstract

We are writing to celebrate the professional life and significant achievements of an information systems scholar, colleague, and a dear friend of ours. Dan passed away unexpectedly on January 26th of this year due to natural causes. We know and have observed Dan's contributions to our field. Not only was Dan an accomplished IS scholar and outstanding faculty member, but also a very active member of professional organizations such as Midwest AIS. The idea of starting MWAIS was developed during a conversation between Dan Power and Troy Strader during the annual AMCIS meeting in Omaha, Nebraska in 2005. Later that year, Ilze Zigurs and 23 others submitted a proposal to found MWAIS on September 7, 2005. Ilze Zigurs helped Dan Power craft the initial by-laws of the newly formed MWAIS. The following excerpts were submitted by Dan's friends and professional associates.

Keywords: Daniel Power

DOI: 10.17705/3jmwa.000067

1. Introduction

On January 26th we lost an outstanding IS scholar, caring faculty member, a constructive leader, and for many of us, a dear friend of more than twenty years. Daniel J. Power passed away due to natural causes. Dan served at the Department of Management, Northern Iowa University, as Professor of Information Systems and Management. He also served as Department Head and Acting Dean of the College. He published a number of books and many scholarly articles in our field. One of his many contributions that numerous colleagues are familiar with, is his well-known and widely used dssresources.com site. Dan served as visiting scholar at many universities around the globe including Brazil, China, Colombia, India, Ireland, Italy, Russia, Spain, and Turkey.

Many of us met Dan at various professional conferences over the years. In the Midwest region, our closer friendship and collaboration with Dan began in 2005 when he played a significant leadership role in the establishment of the Midwest Association of Information Systems (MWAIS). The idea of starting MWAIS was developed during a conversation between Dan Power and Troy Strader during an AMCIS meeting in Omaha, Nebraska in 2005. Later that year, Ilze Zigurs and 23 others submitted a proposal to found MWAIS on September 7, 2005.

Dan was very instrumental in the growth of the MWAIS community. He was always kind and helpful to all colleagues, in particular, newer colleagues in the field who asked for his suggestions and advice. He would not say no to a professional development activity.

During the 2013 ICIS conference in Milan, Rassule Hadidi was serving as the At-Large Director of MWAIS. He approached Dan and mentioned that his proposal was approved by the MWAIS executive committee to start publishing the Journal of Midwest Association for Information Systems (JMWAIS). Rassule asked Dan if he would be willing to serve as Editor-in-Chief. He did not hesitate and said, "sure why not." Dan served in that role from the journal's inception until the day he passed away. The last time Rassule talked to Dan over the phone, January 14th ,2021 was about finalizing the January issue of JMWAIS. Dan will be dearly missed by his numerous friends and associates.

Many colleagues shared fond memories of meeting with Dan, his impacts on their professional careers, and collaborations. Following are some examples.

Gaurav Bansal:

It's a very sad news, Rassule. Dan was a great leader and a very kind-hearted person. I remember in 2012, he visited my house soon after the MWAIS conference along with other committee members. He will always be fondly remembered. I pray to Almighty to give strength to his family and friends to bear this loss.

Dan laid the foundation of Midwest AIS and provided leadership, learning, and networking opportunities for many. Dan was a true visionary who felt a need to create a regional association (MWAIS) to bridge the connection between local businesses, and academia; and provide research and networking opportunities to faculty and students from smaller Universities across the Midwestern region in the US and beyond. His contributions and passion for teaching, research, and enabling students and faculty will be highly remembered.

Many of us will deeply feel the pain of the void created by his passing away.

Mari Buche:

I had the pleasure of meeting Dan Power through participation in the Midwest AIS organization. I served as the MWAIS Treasurer from 2010-2013, and then as the At Large Director. One of the things I looked forward to most was our annual MWAIS meeting, where I was able to reconnect with professional colleagues and friends. Dan and I would discuss research topics, university challenges, and family updates. He was always supportive of my career and served as one of my external reviewers when I sought promotion to Professor.

I will miss Dan's positive attitude, deep knowledge of DSS, quick wit, and supportive friendship. He never hesitated to challenge the status quo whenever he envisioned a better solution. His engaging and often provocative perspective led to intellectual discussions that challenged the assumptions of other participants. For those of us who have shared experiences with him on panels, conference committees, editorial boards, and various professional networks, Dan was always someone you could depend on. He will be missed.

Omar El-Gayar:

I knew Dan for many years and I remember having very nice conversations about the IS disciplines early in my career at DSU. I was also there at the MWAIS conference in Omaha. He will sure be missed. My sincere condolences.

Joey George:

Soon after I joined Iowa State University in 2011, my then department chair asked me to look into hosting the MWAIS meeting in Ames. We held the meeting in 2014, and I served as the conference chair. Putting together this conference was my first real experience with MWAIS and with Dan Power. We had met before, but before the Ames conference, I didn't really know him that well. He was very welcoming to me, as a newcomer to the Midwest, and I grew to look forward to attending as many of the MWAIS conferences as I could. It was always a pleasure to see Dan there, to talk with him about the chapter and the conference and the journal. I vividly remember serving on a panel he organized in Milwaukee. To me, Dan exemplified MWAIS and all it did and all it stood for. He and his leadership will be missed.

Matt Germonprez:

I didn't know Dan very well but my interactions with him were always super positive. He was an incredibly nice man with a gentle smile. One of the specific things that I remember was that I was early in my career and he wanted to hear all about it. It was so sincere and genuine, and totally unexpected. I've always taken that one interaction to heart and remember it every time I'm talking with people who are now starting their own careers. Thanks for that Dan!

Yi "Maggie" Guo:

I cannot recall when was the first time I met Dan. He seemed to always be there, with a smile. I remember vividly in a social event of a conference. I was just a young, first-year assistant professor back then, Dan asked me quite a few questions about my experience settling in a new position and environment. His relaxed and caring manner put me at ease in a circle of senior professors in the field. Over the years, we met often during conferences. He was always supportive and provided me with insights on teaching and research from his long and productive career. He was instrumental in establishing the MWAIS chapter and the journal. His passing away was a great loss to the field of MIS. The best remembrance is to keep him in what we do. Dan is my model of what I should be like when talking to a colleague younger than me.

Deepak Khazanchi:

I have fond memories of working with Dan Power, Rassule Hadidi, Ilze Zigurs, and numerous others on establishing the Midwest AIS chapter and later on the JMWAIS. Dan was soft spoken but a terrific leader of ideas. He led from the back while encouraging lots of young faculty to take ownership of the MWAIS. I will always remember Dan as an indefatigable colleague who truly yearned to regularly engage with our AIS community both regionally and nationally. We were lucky to have him amongst us and remember him with great fondness.

Barbara Klein:

This is very sad news. Thanks for sharing it. Dan was so kind and helpful to me and so many others. My brother, who knew him at UNI, and I are chatting and sharing so many stories about his kindness.

Shana Ponelis:

This is very sad news indeed. Thank you for letting us know. Dan has been a great champion of MWAIS and JMWAIS and a wonderful colleague in the field.

Kevin Scheibe:

I had known of Dan back in my doctoral student days through my research in decision support systems. It seemed you could not perform a search on DSS without his name coming up. I had the pleasure of serving on a panel with Dan and Cliff Ragsdale at a Decision Sciences Institute annual conference, but it was not until I was involved in MWAIS that I really got to know him. Dan was very welcoming and friendly with everyone he interacted with. He was passionate about MWAIS and the Journal of the MWAIS, and his passion was contagious. His absence is a great loss to our community, and he will be sorely missed.

Shu Schiller:

I am so sorry to hear this. I remember Dan and will never forget his impact on the growth of our community and his support to young colleagues.

Troy Strader:

I clearly remember where Dan and I were standing when we talked about the idea for a regional organization. It was in the Omaha Zoo gift shop. I can't believe how fast that 15 years have gone by. I'll always remember walking around New Orleans a few years ago. I never would have thought that Dan would be gone in just a few short years. We all hope that everyone that knew us has such positive memories just like we do with Dan when we are gone.

2. Overview of the Contents of this Issue

This issue of the journal includes two traditional research articles.

In their timely article, Dennis Acuna, Rajab Suliman, and Nasir Elmesmari look at the susceptibilities organizations currently are facing about their digital data and discuss how to better manage exposures. In their quantitative analysis the authors use logistic regression to measure the significance of using ordinal data to evaluate individual intentions to fulfil the Information Assurance policy. The article proposes a methodology to manage organizational Information Assurance policy requirements.

Mary Lebens in this interesting article suggests that the use of design thinking by organizations potentially increases productivity and hence revenue. However, the lack of available design thinking skills limits abilities of organizations to use it. The article effectively demonstrates how design thinking skills can be taught via prototyping in an asynchronous online course.

We appreciate and wish to acknowledge the contributions of reviewers for this issue of the journal, including Mari Buche (Michigan Technological University), Queen Booker, (Metropolitan State University), Bryan Hosack (Penske Logistics), Barbara Klein (University of Michigan, Dearborn), Alanah Mitchell (Drake University), and Shana Ponelis (University of Wisconsin, Milwaukee).

Journal of the Midwest Association for Information Systems

Volume 2021 | Issue 2 Article 2

Date: 07-31-2021

A Practitioner Methodology for Mitigating Electronic Data Risk Associated with Human Error

Dennis C. Acuña, Sc.D.
University of Findlay, acunad@findlay.edu

Rajab Suliman, Ph.D.
University of Toledo, rajab.suliman@utoledo.edu

Nasir Elmesmari, Ph.D.
University of Benghazi, nasir.elmesmari@uob.edu.ly

Abstract

Given the growing importance of data stewardship in today's digital economy, the ability to better manage vulnerabilities associated with electronic data is of interest to organizational leadership. Human error is a vulnerability that increases the likelihood of electronic data risk, such as the threat of a data breach. One countermeasure against human error is the ability to measure human intent toward compliance with an information assurance (IA) policy, as one input for better managing the human factor within an organization. While large organizations are likely to have access to resources for managing the human factor, small to mid-size organizations are less likely to have access to similar resources. Thus, this paper explores the use of commonly available research tools to provide a poor man's countermeasure for better managing the threat/vulnerability pair that is electronic data risk/human error. Our methodology uses logistic regression to evaluate the statistical significance of using ordinal data to measure human intent to comply with an IA policy as such a countermeasure. Our findings conclude that the application of this methodology provides a sound technique for measuring human error vulnerability, and thus better managing electronic data risk.

Keywords: *Logistic regression, ordinal data, information assurance, human error, practitioner*

DOI: 10.17705/3jmwa.000068

1. Background

Electronic data is an organizational feedstock that can be used to achieve objectives and build competitive advantage (Davenport, 2006; Porter, 1979). As such, electronic data is an organizational asset and should be managed as an asset (Collins & Lanz, 2019; Thomson & von Solms, 2005). Despite the existence of governance, risk management and compliance (GRC) best practices for the management of electronic data assets, the frequency of reported data breaches since 2005 continues to increase (Figure 1).

One vulnerability contributing to the frequency of reported data breaches is the human factor, in the form of human error. Warkentin, Straub and Malimage (2012) contend that human error contributes to internal and external threats, which can be non-volitional, non-malicious, and malicious in nature. Dennis and Minas (2018) posit that some human error can be attributed to irrational non-cognitive behavior, as well as rational cognitive behavior. Some industry studies conclude that employee behavior is the largest single cause of security breaches (Johnston, Warkentin, Dennis, & Siponen, 2019), with commercial estimates inferring varying percentages of human error ranging as high as 50% (IBM, 2019; PwC, 2015; Verizon, 2019). Academic researchers Liginlal, Sim and Khansac (2009) posit that up to 65% of data breach incidents resulting in economic loss are attributable to human error. The difference in percentage estimates is not unusual. As shown in Figure 1, the frequency of reported data breaches and associated breached record counts can vary from year to year, but the pattern of reported data breaches and breached records both indicate rising linear trends.

Some studies contend that effective countermeasures can be developed to address these problems (Bulgurcu, Cavusoglu, & Benbasat, 2010; Sasse, Brostoff, & Weirich, 2001), and posit that developing and maintaining a culture of information assurance (IA) is essential for managing the human or behavioral aspect associated with data risk (Da Veiga & Eloff, 2007; Dhillon, Syed, & Pedron, 2016; van Niekerk & von Solms, 2010). One aspect of organizational IA culture, sometimes referred to as IA posture, is human compliance with IA policy (Thomson & von Solms, 2005). Schein (2004) asserts this contention by stating that culture is an abstraction, and that organizations need to understand the forces that result from social and organizational situations, lest they fall victim to them. Other studies have published findings on the effects of a computer security policy on IA culture, and compliance with IA policy (Acuña, 2017; D'Arcy & Hovav, 2007; Da Veiga & Eloff, 2007).

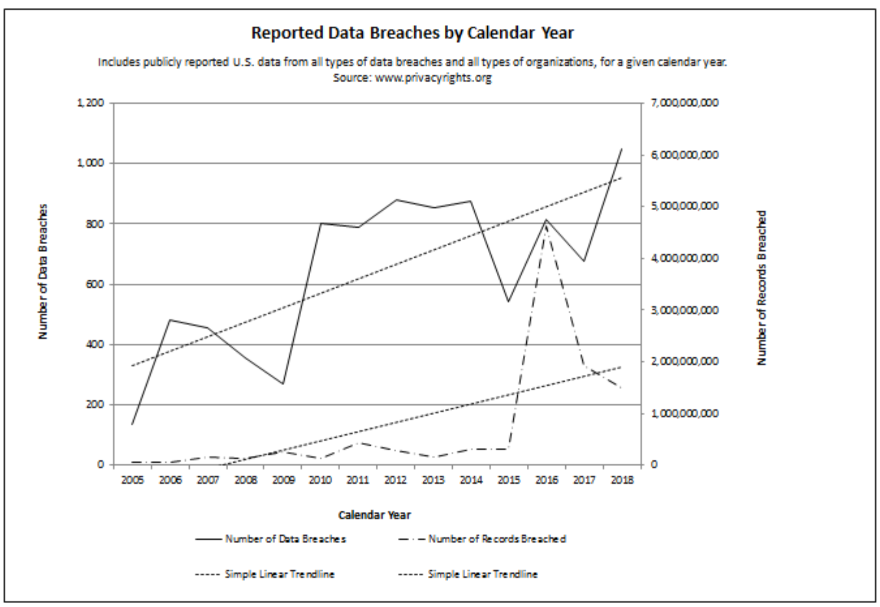


Figure 1. Reported Data Breaches by Calendar Year (Privacy Rights Clearinghouse, 2019)

Although human behavior is difficult to predict, human intent to perform a specific behavior such as complying with an IA policy can be measured (Ajzen, 1991). The theory of planned behavior (TPB) states that human behavior is determined by factors that influence the intention to perform a specific behavior. Rather than model specific human behavior, TPB models behavioral intention. The stronger the intention to perform the behavior, the more likely it is that the specific behavior will be performed. An artifact capable of measuring human intent to comply with an IA policy, such as a survey instrument, would therefore provide a practical technique for the measurement, and subsequent management, of human error vulnerabilities associated with electronic data risk (Liginlal et al., 2009). One instrument commonly used to measure human intent is a Likert scale, a survey tool that records a human response along an ordered scale of qualitative options such as "strongly disagree" to "strongly agree" (Appendix A, Figure A1). Of concern however, is that Likert scales produce data that is ordinal, or non-metric, as opposed to continuous or metric data.

Some researchers posit that the use of ordinal data in statistical analyses should be treated differently than metric data, in that the mode and the median are the accepted measures of central tendency for non-metric data as opposed to use of the mean for metric data (Jamieson, 2004). This belief is not universal, as other researchers support the treatment of ordinal data as interval, or metric, data in statistical analyses (Carifio J. & Perla R., 2007, 2008). While the practice of treating non-metric data as metric data may seem harmless to the practitioner, the application of parametric statistics derived from ordinal data without a strong supporting argument often serves to discredit the reputation of the practitioner, and discount the use of Likert scale instruments and ordinal data as practical research tools (Bishop & Herron, 2015).

2. The Practitioner Problem and Solution

While large organizations are likely to have access to resources for managing the human factor, small to mid-size organizations are less likely to have access to similar resources. As a result, small to mid-sized organizations often face limitation in the number of countermeasures they can deploy, thus weakening IA defenses. Based on the working hypothesis that deployment of a functional, understood countermeasure is better than the absence of such a countermeasure, it is posited that the use of ordinal data and other commonly available research tools be deployed as a poor man's countermeasure for better managing the threat/vulnerability pair that is electronic data risk/human error (Hubbard & Seiersen, 2016). Providing organizational leadership with the ability to capture meaningful, longitudinal measurements on human intent to comply with IA policy can be an effective tool for monitoring and managing the IA culture, or IA posture, of an organization. The use of a Likert scale provides an effective, low cost means for developing such a countermeasure. However there are issues, both positive and negative, associated with this approach (Bishop & Herron, 2015; Carifio J. & Perla R., 2008; Hubbard & Seiersen, 2016; Jamieson, 2004; Joreskog, 2005).

First, Likert scales produce non-metric data which may be unacceptable to some organizations as a meaningful basis for longitudinal measurement. While the mode and median can be used as measures of human intent to comply with IA policy, a more powerful statistical measurement exists in the form of logistic regression, using the receiver operating characteristics (ROC) curve and the area under the ROC curve (AUC).

Second, Likert scales are administered at the individual level and not the organizational level, which may be viewed by some as an ineffective measurement for developing security education training and awareness (SETA) guidance at the organizational level. However, the input of individually sourced ordinal responses to build a logistic regression model and the interpretation of the composite output ROC/AUC statistics provides guidance for managing IA posture at the organizational level.

Thus, the remainder of this paper discusses the use of commonly available research tools in the form of Likert scales, ordinal data, the R computer program, and logistic regression, to develop a poor man's countermeasure that is both efficient and effective for managing the threat/vulnerability pair that is electronic data risk/human error.

3. Research Objective and Hypotheses

To better manage the threat/vulnerability pair that is electronic data risk/human error, a practical, statistically viable artifact capable of measuring human intent to comply with an IA policy is desired. Thus, the research objective of this study is to determine the statistical viability of using an ordinal scale survey instrument to measure and classify human respondents into two categories; those who intend to comply with an IA policy, and those who do not intend to comply with IA policy.

Table 1. Research Hypotheses

Null Hypothesis	Alternative Hypothesis
H_0: A survey instrument utilizing an ordinal scale is not a statistically significant instrument for measuring human intent to comply with an IA policy.	H_a: A survey instrument utilizing an ordinal scale is a statistically significant instrument for measuring human intent to comply with an IA policy.

Therefore, it is the hypothesis of this study that an ordinal scale survey instrument, often referred to as a Likert scale, can be used to measure human intent to comply with an IA policy (Table 1).

4. Research Methodology

4.1 Research Background

This study is an extension of original, institutional review board (IRB) approved research into the effects of a comprehensive IA policy on human compliance with IA policy (Acuña, 2017). As such, this paper leverages an existing dataset.

4.2 Survey Design and Operalization

The IRB approved survey instrument for the original study (Acuña, 2017) utilized a 7-point Likert scale for measurement. Measurement of TPB indicators in information systems (IS) research is mixed, with evidence of unipolar and bipolar, 5-point and 7-point Likert scales. The IRB approved survey instrument adopted the unipolar 7-point Likert scale recommended by Ajzen (1991) for measurement (Appendix A, Figure A1).

Questions for the IRB approved survey instrument (Appendix A, Table A2) were drawn, when possible, from previous studies conducted within this domain (Flores & Ekstedt, 2016; Guo, Yuan, Archer, & Connelly, 2011; Pavlou & Fygenson, 2006). Six demographic control variables were utilized: IT/OT identity, gender, age, education, years of work experience, and industry sector (Appendix A, Table A1). A modified three-sector theory construct (primary, secondary, tertiary, quaternary) served as the basis for the industry sector model (Fisher, 1939). The inclusion of industry sector as a control variable aligns with the contention by Bulgurcu et al. (2010) that some industries are more vulnerable to computer security issues than other industries.

Questionnaire distribution and data collection for the IRB approved survey was contracted to Qualtrics (2020), a commercial Internet service that specializes in survey based research. The target population was experienced, industry based, authorized users located in the United States, randomly selected from various industry sectors. Identifiers capable of linking a response to a participant, including Internet Protocol (IP) address, were managed by Qualtrics and were hidden and unknown to the principal investigator. Operationalization of the survey instrument resulted in the collection of 210 responses. A summarization of the collected responses was presented at an academic conference and subsequently published in the conference proceedings (Acuña, 2018). For readability of this paper, a summarization of the Likert scale, demographic frequency distributions, and questionnaire responses is included in Appendix A of this report.

4.3 Data Analysis Technique

Given the ordinal dataset used for this paper, and the research objective of measuring and classifying human intent into the binary categories of complying with an IA policy or not complying with an IA policy, logistic regression was selected as the primary technique for data analysis. Logistic regression is a technique for modeling the relationship between multiple independent variables and a binary categorical dependent variable (Park, 2013). Use of logistic regression is an appropriate statistical analysis technique when the dependent variable is non-metric with two possible outcomes, and independent variables are metric or non-metric. Logistic regression is often used to address research objectives associated with establishing a classification system for determining group membership (Hair, Black, Babin, & Anderson, 2010). The Microsoft Windows R platform (R Core Team, 2019) was selected as the computer software for executing the analysis.

4.4 Sample Size

The minimal sample size for multiple logistic regression is the minimum number of observations needed to execute the logistic regression model. The factors involved in determining sample size include statistical power, predictor variables, smallest proportion of binary cases, effect size, and standard error, making sample size estimation for multiple logistic regression a complex effort (Park, 2013). Peduzzi, Concato, Kemper, Holford and Feinstein (1996) contend that minimal sample size is defined as $n = 10k/p$, where k represents the number of predictor variables and p denotes the smallest proportion of binary cases in the population, with (1) indicating that the event occurred and (0) indicating that the event did not occur (Park, 2013). Additionally, if the calculated number of observations is less than 100, it is recommended that the sample size be increased to 100 (Long, 1997). Based on a Likert scale cutoff point of 6, the proportion of binary cases for our dataset resulted in 156 (1's) and 54 (0's), resulting in the value of 54 as the smaller binary proportion. As shown in Table 2, the minimal sample size for a six predictor model is 234, rounded up from the calculated value of 233.333. The minimal sample size for a two predictor model is calculated at 77.778 and rounded up to 100, given that the calculated sample size is less than 100.

Table 2. Logistic Regression Sample Size *n = 10k/p*

	k	***p***		***n***
Constant	**Predictor Variables**	**Binary Case Proportion**	**Calculated Sample Size**	**Adjusted Sample Size**
10	6	54/210	233.333	234
10	2	54/210	77.778	100

In addition to the formula suggested by Peduzzi et al. (1996) and the guideline recommended by Long (1997), other researchers posit different formulas for minimal sample size. Hosmer and Lemeshow (2000) recommend sample sizes greater than 400, while Hair et al. (2010) suggest a sample size based on dependent variable groups, with each group consisting of 10 observations per estimated parameter. Lastly, we note that simply rounding the six predictor *p* value in Table 2 to one decimal place yields a calculated sample size of 200 observations instead of 233.33 observations. Given the range of formulas for sample size, the different sample sizes produced by each formula, and the sensitivity of sample size to binary case proportion, we conclude that our dataset of 210 observations, while less than the Peduzzi et al. (1996) recommended 234 observations for a six predictor model, provides working representation for our study.

4.5 Empirical Strategy

To ensure statistical significance, a link function was used to transform the linearity between the predictor variables and the response variable, with the most common choice being use of the logit function (Zuur, Ieno, Walker, Saveliev, & Smith, 2009). The logit function ensures that any transformed value from the linear predictor variables will be restricted to the range of 0 . . . 1 (Douma & Weedon, 2019). Based on the input dataset, logistic regression produces an S-shaped curve of predicted probability values ranging between 0 . . . 1. The probability values are calculated from the values of the independent variables and their estimated coefficients. Predicted probabilities > 0.50 result in a value of (1) indicating that the event occurred, while values ≤ 0.50 result in a value of (0) indicating that the event did not occur (Hair et al., 2010). The following sections describe our analysis and findings resulting from the use of logistic regression to measure and classify human respondents into two categories; those who intend to comply with an IA policy, and those who do not intend to comply with an IA policy.

4.6 Overall Model Evaluation

The model created for this study produced the goodness-of-fit statistics listed in Table 3. Given that a likelihood ratio (MLE) with a low p-value (0.015) indicates good model fit, and a Hosmer-Lemeshow test with a high p-value (0.606) is also indicative of good model fit, the findings in Table 3 suggest similar conclusions; that the fitted model including all predictor variables is more effective than the null model, leading to the conclusion that the fitted model is meaningful (Park, 2013).

Table 3. Overall Model Evaluation and Goodness-of-Fit Statistics (n = 170)

Test Name	Test Purpose	Significant p-value	p-value
Likelihood ratio test (MLE)	Model parameter evaluation	Low	0.015 (*)
Hosmer-Lemeshow test	Lack of model fitness	High	0.606

This study utilized six demographic control variables as classifiers: IT/OT identity, gender, age, education, years of work experience, and industry sector. Demographic sub-categories containing fewer than five observations were combined with contiguous sub-categories to minimize error (McDonald, 2009). Given a survey dataset representing 210 respondents, the R model was programmed to segment the dataset as 80% training data and 20% test data. This resulted in a training dataset of approximately 170 random respondents and a test dataset of approximately 40 random respondents. Each of the following tables and figures represent the training dataset of 170 random respondents.

Table 4 displays the significance of the individual relationships between the control variables based on the Wald Chi-Square test. The only independent variables that are statistically significant classifiers for the event are age with $\alpha = 0.05$ and education with $\alpha = 0.10$. Based on this finding we repeated the analysis by dropping the factors associated with the highest p-values. This action lead to the same conclusion, that only age and education offer significant contribution to the event.

Table 4. Statistical Significance of Regression Coefficients Using Wald Chi-Square Test

Variable	Estimate	Std. Error	z-value	p-value
(Intercept)	-2.530	1.057	-2.394	0.017 (*)
IT/OT	0.198	0.472	0.42	0.674
Male/Female	0.385	0.438	0.879	0.379
Age3	2.095	0.673	3.112	0.002 (**)
Age4	1.574	0.736	2.139	0.032 (*)
Age5	1.753	0.809	2.166	0.030 (*)
Age6	0.901	1.015	0.888	0.375
Education3	1.219	0.741	1.647	0.100 (.)
Education5	-0.375	0.804	-0.467	0.641
Education6	0.496	0.663	0.748	0.454
Education8	0.079	0.755	0.104	0.917
WorkExperience3	0.817	0.514	1.589	0.112
WorkExperience4	0.024	0.608	0.039	0.969
WorkExperience5	1.123	0.709	1.585	0.113
IndustrySector2	0.775	0.808	0.959	0.338
IndustrySector4	0.994	0.811	1.226	0.220

4.7 Predictive Accuracy

The classification confusion matrix for the training data using all control variables (Table 5) displays the predictive accuracy of the logistic regression model (Peng & So, 2002).

Table 5. Classification Confusion Matrix of Training Data with All Control Variables

	Predicted		
Actual	**Yes**	**No**	**% Correctly predicted**
Yes	$n_{11} = 114$	$n_{10} = 35$	76.51% sensitivity
No	$n_{01} = 8$	$n_{00} = 13$	61.90% specificity
Overall % correct			74.71% overall correct

$$Sensitivity = \ 114/(114 + 35) = 76.51\%\,; Specificity = \ 13/(8 + 13) = 61.90\%$$

The 2x2 matrix for predicted values displays the cross classification of the observed values for the response variable and the predicted values at the defined cut-off value. A default cut-off value of 0.5 was used, with predicted values > 0.5 classified as human intent to comply (1) with an IA policy, and predicted values ≤ 0.5 classified as human intent to not comply (0) with an IA policy. The 2x2 matrix for predicted values using all control variables (Table 5) is summarized as a dichotomous observed response and a dichotomous predicted response. Given that the fitted model exhibits goodness-of-fit (Table 3), we expect to see a high count of correctly predicted values of the actual classes likely to comply (1) versus not likely to comply (0). The ability to correctly predict a class (1) observation is commonly known as sensitivity and is calculated as $n_{11}/(n_{11} + n_{10})$. Specificity is the ability to correctly predict class (0) and is calculated as $n_{00}/(n_{01} + n_{00})$. As shown in Table 5, the overall correct prediction of 74.71% indicates an improvement over a 50% level of chance. Higher percentages of sensitivity and specificity indicate a fitted model with better classification performance. This finding aligns with an overall correct accuracy of 80% produced by executing the fitted model with the test dataset.

Table 6 displays the confusion matrix after dropping non-significant factors. Dropping non-significant factors improves the overall accuracy to 75.88% (Table 6) from 74.71% (Table 5), compared to when all six control variables are modeled. This finding is a good indication that the model is preforming well.

Table 6. Classification Confusion Matrix of Training Data with Age and Education Only

	Predicted		
Actual	**Yes**	**No**	**% Correctly predicted**
Yes	$n_{11} = 117$	$n_{10} = 36$	76.47% sensitivity
No	$n_{01} = 5$	$n_{00} = 12$	70.59% specificity
Overall % correct			75.88% overall correct

$Sensitivity = 117/(117+36) = 76.47\%; Specificity = 12/(5+12) = 70.59\%$

4.8 Discrimination with ROC Curves and AUC

Extending the 2x2 matrix referenced in Table 5, all data values are examined without the benefit of a single cutoff point. The resulting analysis produces a scatter plot of values ranging between 0 . . . 1, such that data pairs (x, y) or (1-specificity, sensitivity) define the area representing the receiver operating characteristics curve (ROC) (Berrar & Flach, 2012). The area under the ROC curve (AUC) provides the overall performance of the fitted logistic regression model (Bewick, Cheek, & Ball, 2004).

As depicted in Figure 2 and Figure 3, data points below the diagonal line dividing the ROC space represent poor model performance (worse than random), while data points above the diagonal line indicate good model performance (better than random). Higher AUC values suggest better predictability of the fitted model (Park, 2013).

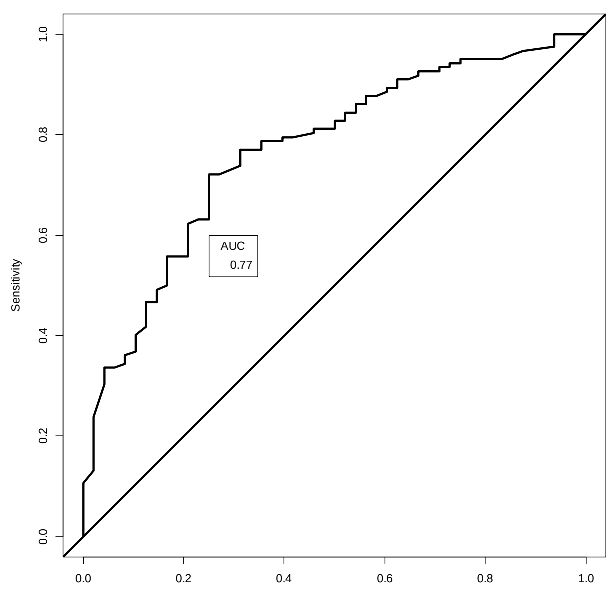


Figure 2. AUC (76.8%) for Six Control Variables

Figure 2 depicts the AUC for the six demographic control variables defined within this study. As indicated, modeling six variables results in an AUC of 0.768, compared with an AUC of 0.739 (Figure 3) when only age and education are modeled.

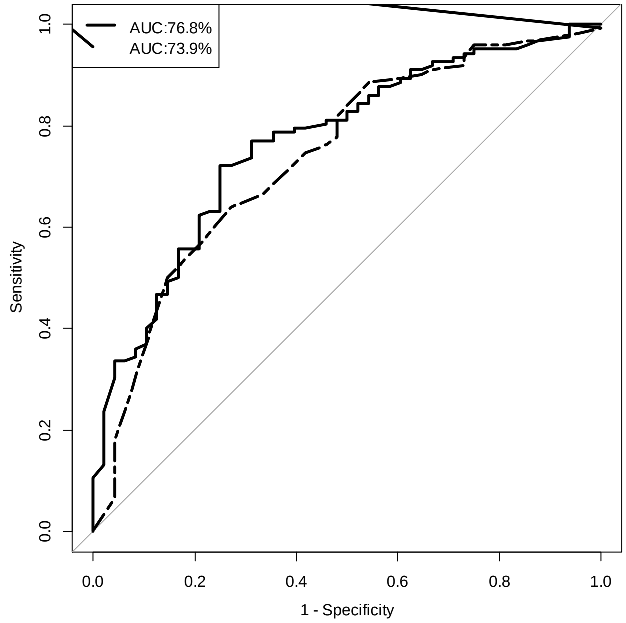


Figure 3. AUC (73.9%) for Two Control Variables (Age and Education)

Using R function *test.roc* we found no statistically significant difference in AUCs when modeling all six control variables or modeling only two control variables: age, and education (z = 0.877, p-value = 0.381). In conclusion, we find that age and education are good classifiers for measuring human intent to comply with an IA policy.

Figure 4 depicts the Pearson residual plot versus the estimated probability for the model. In this instance, the LOWESS smoothing approximates a line having zero slope and a near zero intercept. We conclude there is no significant model inadequacy.

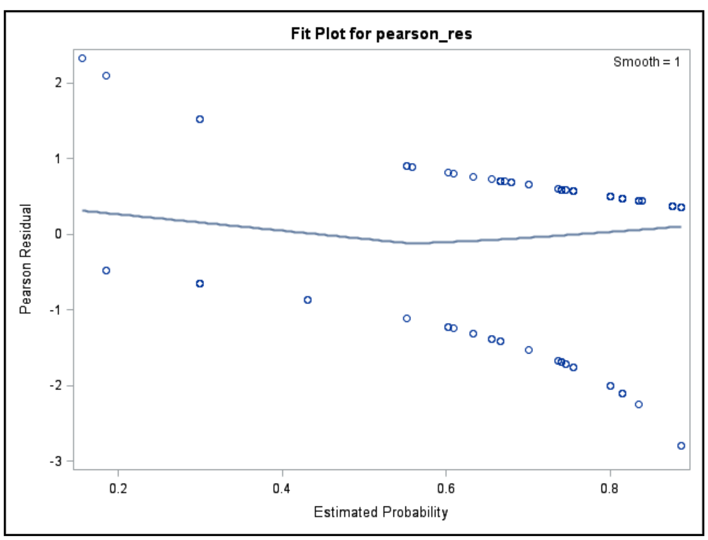


Figure 4. Residual Plot with LOWESS Smoothing

AUC values (Table 7) range in performance from no discrimination (AUC = 0.5) to outstanding discrimination (AUC > 0.9). The terminology describing AUC performance varies among researchers, with different qualitative attributes describing the same quantitative performance (Table 7). Our findings are consistent with acceptable/excellent discrimination.

Table 7. AUC Discrimination Levels and Performance Attribute

AUC Discrimination Range	Performance Attribute (Mandrekar, 2010)	Performance Attribute (Yang & Berdine, 2017)
$\text{AUC} = 0.5$	No discrimination	No discrimination
$0.5 < \text{AUC} \leq 0.6$		Poor discrimination
$0.6 < \text{AUC} \leq 0.7$		Acceptable discrimination
$0.7 < \text{AUC} \leq 0.8$	Acceptable discrimination	Excellent discrimination
$0.8 < \text{AUC} \leq 0.9$	Excellent discrimination	
$0.9 < \text{AUC}$	Outstanding discrimination	Outstanding discrimination

5. Research Limitations

5.1 Likert Scale Cutoff Point

The Likert scale cutoff point for categorization was set at 6, meaning that survey responses ≥ 6 were categorized as (1) indicating that the event occurred, and survey responses < 6 were categorized as (0) indicating that the event did not occur. The cutoff point of 6 was selected based on the fact that the dataset exhibited negative (left) skewness with the mode falling consistently in the 6-7 range of the Likert scale (Appendix A, Figure A1, Table A2). This logic also suggested that selecting 6 as the cutoff point on a 7 point Likert scale minimized outcome bias in regard to categorization of survey responses.

5.2 Sample Size

Setting the Likert scale cutoff point also has an effect on the sample size calculation used by this paper. For the dataset used by this paper, lowering the cutoff point results in more (1's) which reduces the proportion of (0's), which increases the minimal sample size. Raising the cutoff point results in more (0's) which increases the proportion of (0's), which decreases the minimal sample size. While our sample size of 210 is less than the Peduzzi et al. recommendation of 234, raising the Likert scale cutoff point from ≥ 6 to = 7 would result in a sample size approximating 210 observations. Thus, given the sensitivity of sample size to the Likert scale cutoff point and rounding preferences, we conclude that our dataset of 210 observations provides working representation for our study. We note that future work would benefit from a study of the different formulas for calculating logistic regression minimal sample size, and from sensitivity analysis of the variables used in the sample size formula.

6. Research Findings and Practitioner Contribution

6.1 Research Findings

Based on the results of our analysis, we reject the null hypothesis and accept the alternative hypothesis that an ordinal scale survey instrument is a statistically significant instrument for measuring human intent to comply with an IA policy. We also find that the application of logistic regression on the dataset produced from an ordinal scale survey instrument is a practical technique for classifying human respondents into two categories; those who intend to comply with an IA policy, and those who do not intend to comply with an IA policy. Among these findings we determine that age and education are good classifiers for measuring human intent to comply with an IA policy, and that the fitted model including all predictor variables is more effective than the null model, leading to the conclusion that the fitted model as described by this paper is meaningful.

6.2 Practitioner Contribution

Use of a Likert scale survey instrument and the data analysis technique described in this paper provide a practical, statistically viable means to measure and classify human intent to comply with an IA policy. Longitudinal application of this methodology on the members of an organizational body will provide the practitioner with consistent, predictive measurement in the form of statistics that are representative of an organization's intent to comply or not comply with an IA policy. These statistics can be used to graph change over time, thus providing a visual metric of whether organizational IA posture is improving, plateauing, or worsening.

6.3 A Poor Man's Countermeasure

An example of a graph leveraging the commonly available research tools discussed in this paper is depicted in Figure 5. The graph titled "IA Posture and AUC Discrimination" is an example of imaginary performance regarding an organizational SETA program. The data shown in this graph is artificial and is not real, and is used for illustrative and explanatory purposes only. We break down each graph component and its intended meaning as follows.

As prescribed by our imaginary SETA program, a survey instrument is administered to our organizational workforce on an annual basis. The survey instrument collects data on the six demographic control variables used by this study which are now used as predictor variables. If permitted, the demographic data might be readily obtainable from the human resources department, in which case a survey instrument will not be needed. The control variables are input into our previously fitted logistic regression model which outputs (predicts) the number of people likely to comply with an IA policy (1), and the number of people not likely to comply with an IA policy (0). The percentage of (1's) is then inserted into the data table as the data series titled "IA Posture". This process is repeated on an annual basis.

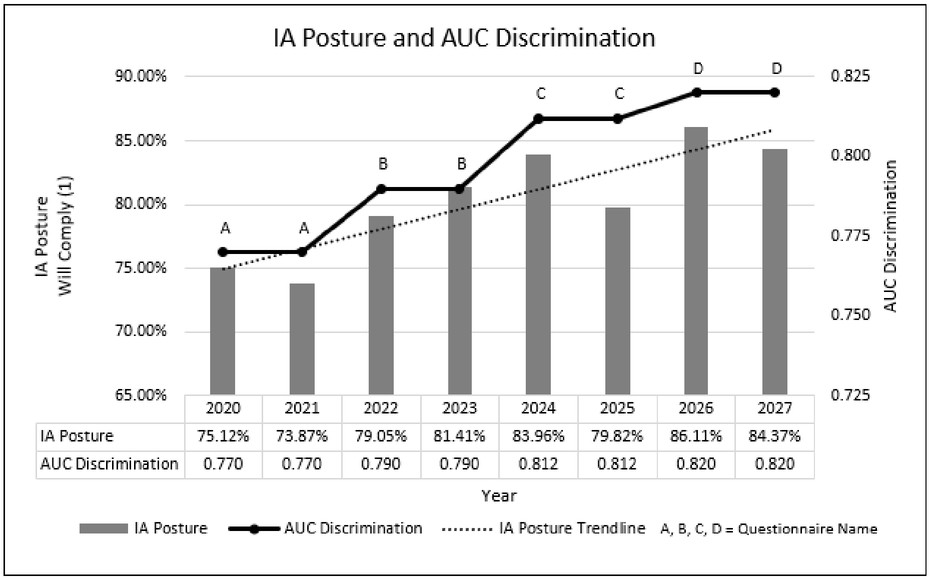


Figure 5. Example of a Poor Man's Countermeasure

Our graph also depicts the use of different Likert scale survey instruments over time, annotated as questionnaires *A*, *B*, *C*, and *D*. Each questionnaire is used for two years to provide a basis for comparison of performance management, and then modified to adjust for current findings and relevant concerns. Modification of the questionnaire and its associated questions requires us to rebuild our fitted logistic regression model every two years, which results in a new AUC predictor value represented within the data series "AUC Discrimination". The AUC discrimination statistic represents the predictive strength of our fitted logistic regression model (Park, 2013). High AUC values (Table 7) suggest better predictability of the fitted model while low AUC values suggest weaker predictability.

Examining IA posture for the year 2020, we note our fitted model predicted 75.12% of the workforce would comply with our IA policy. We are confident that this finding is significant, in that the AUC discrimination for questionnaire *A* is 0.770 which is indicative of acceptable/excellent discrimination (Table 7). Other years on the graph are interpreted in the same manner. A trendline for the data series "IA Posture" is added for good measure, the upward trend suggesting that our SETA program is having the desired effect on our workforce.

Of note is that IA Posture dipped in the years 2021, 2025, and 2027. The dips are signals to organizational leadership that the IA posture for our workforce has worsened from the previous year in regard to willingness to comply with our IA policy, and that an adjustment is needed in our SETA program. Given the binary classification output of our model, personalized SETA messages can be crafted for each classification to elicit the desired IA behavior (Johnston et al., 2019). Based on the improved results in 2022 and 2026, we surmise that the adjustments to our SETA program had the desired effect and that organizational IA posture is back on track. A similar adjustment will need to be made prior to delivery of the 2028 survey instrument. We also conclude that our IA support team is improving, as the re-fitted models are producing stronger AUC discrimination statistics over time, thus ensuring confidence in organizational leadership that our SETA program is effective.

7. Conclusion

In conjunction with other IA GRC best practices, application of the methodology outlined in this paper constitutes a poor man's countermeasure for managing organizational IA posture, using commonly available research tools. While not perfect, deployment of a functional, understood countermeasure is better than the absence of such a countermeasure, thus providing organizations with a practical methodology for mitigating electronic data risk associated with human error. As stated by Hubbard and Seiersen (2016), "A mere reduction, not necessarily an elimination, of uncertainty will suffice for a measurement" (p. 21).

8. References

Acuña, D. C. (2017). *Effects of a Comprehensive Computer Security Policy on Human Computer Security Policy Compliance*. Doctoral Dissertation Final Defense. Dakota State University. Madison, SD.

Acuña, D. C. (2018). *Manifest Observations on a Comprehensive Computer Security Policy.* Paper presented at the Proceedings of the Thirteenth Midwest Association for Information Systems Conference, Paper 59, University of Missouri-St. Louis.

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179-211.

Berrar, D., & Flach, P. (2012). Caveats and Pitfalls of ROC Analysis in Clinical Microarray Research (and how to avoid them). *Briefings in Bioinformatics, 13*(1), 83-97.

Bewick, V., Cheek, L., & Ball, J. (2004). Statistics Review 13: Receiver Operating Charachteristic Curves. *Critical Care, 8*(6), 508.

Bishop, P. A., & Herron, R. L. (2015). Use and Misuse of the Likert Item Responses and Other Ordinal Measures. *International Journal of Exercise Science, 8*(3), 297-302.

Bulgurcu, B., Cavusoglu, H., & Benbasat, I. (2010). Information Security Policy Compliance: An Empirical Study of Rationality-Based Beliefs and Information Security Awareness. *MIS Quarterly, 34*(3), 523-A527.

Carifio J., & Perla R. (2007). Ten Common Misunderstandings, Misconceptions, Persistent Myths and urban legends about Likert scales and Likert response Formats and their Antidotes. *Journal of Social Sciences, 3*(3), 106-116.

Carifio J., & Perla R. (2008). Resolving the 50-year Debate Around using and Misusing Likert Scales. *Medical Education, 42*(12), 1150-1152.

Collins, V., & Lanz, J. (2019). Managing Data as an Asset. *CPA Journal, 89*(6), 22-27. Retrieved from https://login.ezproxy.findlay.edu/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bft&AN=136901846&site=ehost-live

D'Arcy, J., & Hovav, A. (2007). Deterring Internal Information Systems Misuse. *Communications of the ACM, 50*(10), 113-117.

Da Veiga, A., & Eloff, J. H. P. (2007). An information security governance framework. *Information Systems Management, 24*(4), 361-372.

Davenport, T. H. (2006). Competing on Analytics. *Harvard Business Review, 84*(1), 98-107. Retrieved from http://www.ezproxy.dsu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=keh&AN=19117901&site=ehost-live&scope=site

Dennis, A. R., & Minas, R. K. (2018). Security on Autopilot: Why Current Security Theories Hijack our Thinking and Lead Us Astray. *SIGMIS Database, 49*(SI), 15–38.

Dhillon, G., Syed, R., & Pedron, C. (2016). Interpreting information security culture: An organizational transformation case study. *Computers & Security, 56*, 63-69.

Douma, J. C., & Weedon, J. T. (2019). Analysing continuous proportions in ecology and evolution: A practical introduction to beta and Dirichlet regression. *Methods in Ecology and Evolution, 00*, 1-19.

Fisher, A. G. B. (1939). Production, Primary, Secondary and Tertiary. *Economic Record, 15*, 24–38.

Flores, W. R., & Ekstedt, M. (2016). Shaping intention to resist social engineering through transformational leadership, information security culture and awareness. *Computers & Security, 59*, 26-44.

Guo, K. H., Yuan, Y., Archer, N. P., & Connelly, C. E. (2011). Understanding Nonmalicious Security Violations in the Workplace: A Composite Behavior Model. *Journal of Management Information Systems, 28*(2), 203-236. Retrieved from http://www.ezproxy.dsu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=67194187&site=ehost-live&scope=site

Hair, J. F., Jr., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate Data Analysis* (7th ed.): Prentice Hall.

Hosmer, D. W., & Lemeshow, S. (2000). *Applied Logistic Regression* (2nd ed.). New York, NY: John Wiley & Sons, Inc.

Hubbard, D. W., & Seiersen, R. (2016). *How to Measure Anything in Cybersecurity Risk*. Hoboken, NJ: John Wiley & Sons, Inc.

IBM. (2019). IBM Study Shows Data Breach Costs on the Rise; Financial Impact Felt for Years. Retrieved from https://newsroom.ibm.com/2019-07-23-IBM-Study-Shows-Data-Breach-Costs-on-the-Rise-Financial-Impact-Felt-for-Years

Jamieson, S. (2004). Likert scales: how to (ab)use them. *Medical Education, 38*(12), 1217-1218.

Johnston, A. C., Warkentin, M., Dennis, A. R., & Siponen, M. (2019). Speak their Language: Designing Effective Messages to Improve Employees' Information Security Decision Making. *Decision Sciences, 50*(2), 245-284.

Joreskog, K. G. (2005). *Structural Equation Modeling with Ordinal Variables using LISREL*.

Liginlal, D., Sim, I., & Khansac, L. (2009). How significant is human error as a cause of privacy breaches? An empirical study and a framework for error management. *Computers & Security, 28*.

Long, J. S. (1997). *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks, CA: Sage Publications.

Mandrekar, J. N. (2010). Receiver Operating Characteristic Curve in Diagnostic Test Assessment. *Journal of Thoracic Oncology, 5*(9), 1315-1316.

McDonald, J. H. (2009). *Handbook of Biological Statistics* (Second ed. Vol. 2). Baltimore, MD: Sparky House Publishing.

Park, Hyeoun-Ae. (2013). An Introduction to Logistic Regression: From Basic Concepts to Interpretation with Particular Atention to Nursing Domain. *Journal of Korean Academic Nursing, 43*(2), 154-164.

Pavlou, P. A., & Fygenson, M. (2006). Understanding and Predicting Electronic Commerce Adoption: An Extension of the Theory of Planned Behavior. *MIS Quarterly, 30*(1), 115-143. Retrieved from http://www.ezproxy.dsu.edu:2048/login?url=http://search.ebscohost.com/login.aspx?direct=true&db=buh&AN=19754863&site=ehost-live&scope=site

Peduzzi, P., Concato, J., Kemper, E., Holford, T. R., & Feinstein, A. R. (1996). A Simulation Study of the Number of Events per Variable in Logistic Regression Analysis. *Journal of Clinical Epidemiology, 49*(12), 1373-1379.

Peng, C. Y. J., & So, T. S. H. (2002). Logistic Regression Analysis and Reporting: A Primer. *Understanding Statistics: Statistical Issues in Psychology, Education, and the Social Sciences, 1*(1), 31-70.

Porter, M. E. (1979). How competitive forces shape strategy. *Harvard Business Review, 57*(2), 137-145.

Privacy Rights Clearinghouse. (2019). Data Breach Chronology. Retrieved from http://www.privacyrights.org/data-breach

PwC. (2015). *2015 Information Security Breaches Survey*. Retrieved from http://www.pwc.co.uk/assets/pdf/2015-isbs-technical-report-blue-03.pdf

Qualtrics. (2020). Online Survey Platform. Retrieved from https://www.qualtrics.com/

R Core Team. (2019). R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. Retrieved from https://www.R-project.org/

Sasse, M. A., Brostoff, S., & Weirich, D. (2001). Transforming the 'Weakest Link' -- a Human/Computer Interaction Approach to Usable and Effective Security. *BT Technology Journal*, *19*(3), 122.

Schein, E. H. (2004). *Organizational Culture and Leadership* (3rd ed.). San Francisco, CA: Jossey-Bass.

Thomson, K. L., & von Solms, R. (2005). Information security obedience: a definition. *Computers & Security*, *24*(1), 69-75. Retrieved from http://www.sciencedirect.com/science/article/pii/S0167404804002627

van Niekerk, J. F., & von Solms, R. (2010). Information security culture: A management perspective. *Computers & Security*, *29*(4), 476-486.

Verizon. (2019). 2019 Data Breach Investigations Report. Retrieved from https://enterprise.verizon.com/resources/reports/dbir/

Warkentin, M., Straub, D., & Malimage, K. (2012). *Featured Talk: Measuring Secure Behavior: A Research Commentary*. Paper presented at the Annual Symposium on Information Assurance & Secure Knowledge Management, Albany, NY.

Yang, S., & Berdine, G. (2017). The receiver operating characteristic (ROC) curve. *The Southwest Respiratory and Critical Care Chronicles*, *5*(19), 34-36.

Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). *Mixed Effects Models and Extensions in Ecology with R*. New York: Springer.

9. Appendix A

Survey Instrument and Data Summarization (Acuña, 2018)

1	2	3	4	5	6	7
Strongly Disagree	Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Agree	Strongly Agree

Figure A1. Unipolar 7-Point Likert Scale for Belief Strength Measurement (Variable ID H11-HA3)

Table A1. Participant Demographics (percentages subject to rounding error)

Demographic	**Category**	**Frequency Σ** (n=210)	**Percent Σ** (n=210)	**Frequency IT** (n=106)	**Frequency OT** (n=104)
Identity	Information Technology (IT)	106	50.48%	106	0
	Operational Technology (OT)	104	49.52%	0	104
Gender	Male	148	70.48%	71	77
	Female	62	29.52%	35	27
Age	Less than 18 years old	0	0.00%	0	0
	18 to 24 years old	20	9.52%	12	8
	25 to 34 years old	82	39.05%	42	40
	35 to 44 years old	45	21.43%	24	21
	45 to 54 years old	43	20.48%	25	18
	55 to 64 years old	19	9.05%	3	16
	65 years or older	1	0.48%	0	1
Education	Some high school, but no diploma	2	0.95%	0	2
	High school diploma or equivalent (GED)	18	8.57%	7	11
	Some college credit, but no degree	32	15.24%	14	18
	Trade/technical/vocational certificate	8	3.81%	4	4
	Associate's degree	20	9.52%	9	11
	Bachelor's degree	92	43.81%	49	43
	Some graduate school work, but no graduate degree	5	2.38%	3	2
	Master's degree	25	11.90%	16	9
	Doctorate degree	8	3.81%	4	4
Work Experience	Less than 1 year	5	2.38%	3	2
	1 to 5 years	50	23.81%	21	29
	6 to 10 years	73	34.76%	37	36
	11 to 15 years	34	16.19%	22	12
	16 to 20 years	24	11.43%	13	11
	21 to 25 years	12	5.71%	6	6
	26 to 30 years	8	3.81%	4	4
	31 to 35 years	3	1.43%	0	3
	36 years or more	1	0.48%	0	1
Industry Sector	Extraction of natural resources	12	5.71%	9	3
	Transformation of natural resources	86	40.95%	19	67
	Physical service provider	20	9.52%	8	12
	Knowledge based service provider	92	43.81%	70	22

Table A2. Manifest Observations (Mode) on a Comprehensive Computer Security Policy

Variable ID	**Manifest Observation on a Comprehensive Computer Security Policy**	**Mode Σ** (n=210)	**Mode IT** (n=106)	**Mode OT** (n=104)
H11	My coworkers agree that I should comply with the new policy.	6	6	6
H12	My coworkers will think that I should comply with the new computer security policy.	6	6	6
H13	My supervisor will want me to comply with this new policy.	7	7	6
H21	It is important that I convince my coworkers to comply with the new computer security policy.	7	7	6
H22	My coworkers rely on my opinion.	6	7	6
H23	The new policy is important and others need to know how I feel about it.	6	7	6
H31	I will be reprimanded if my organization is aware of my non-secure actions.	7	7	6
H32	My management notices when I follow security procedures, and encourages me to keep doing a good job!	6	6	6
H33	I am encouraged when the company notices I am following security procedures.	6	7	6
H41	As a professional, I have to do certain things on my job. Strictly following computer security policies is one of them.	6	7	6
H42	Following computer security rules and policies is an important part of what I do as a professional.	7	7	6
H43	Breaking security policies hurts my image as a professional.	7	7	7
H51	This security policy helps to secure all computer systems.	7	7	6
H52	This security policy is absolutely necessary.	7	7	6
H53	This security policy is important.	7	7	6
H61	I understand the risks posed by poor security and that I may be reprimanded if I don't comply with policy.	7	7	7
H62	I am aware of the potential threats and negative consequences that are possible if I don't follow the proper security procedures.	7	7	6
H63	It is important that I follow the rules for keeping my organization secure so that I don't get into trouble.	7	7	7
H71	My co-workers and I agree that complying with the new policy is the right thing to do.	6	7	6
H72	It is important to me that my co-workers comply with the new policy.	7	7	6
H73	It is important that my co-workers know that I intend to comply with the new computer security policy.	7	7	7
H81	I believe that complying with the new security policy is a good idea.	7	7	7
H82	I think that complying with the new security policy is the right thing to do.	7	7	7
H83	By complying with the new security policy I am helping the company stay secure from computer threats.	7	7	6
H91	Complying with the new policy helps to improve my job performance.	6	7	6
H92	Complying with the new policy lets me perform my tasks more effectively.	6	6	6
H93	Complying with the new policy makes it easier for me to do my job.	6	7	6
HA1	I am confident that I will comply with the new computer security policy.	7	7	7
HA2	I understand the benefits of the new computer security policy and I intend to comply with it.	7	7	6
HA3	Regardless of how others think or act, I intend to comply with the new computer security policy.	7	7	6

Author Biographies

Dennis C. Acuña is an information systems and information technology practitioner, with 36 years of hands-on experience in the oil and gas industry. He holds a doctorate in information systems from Dakota State University (2017) and currently teaches courses in information security, risk management for information systems, and information technology management at the University of Findlay, and the University of Toledo. He conducts original, empirical research in the field of information assurance and presents his findings at industry and academic conferences, along with publication in peer-reviewed academic journals. In addition to teaching and research activities, Acuña works as an independent, information systems governance, risk management, and compliance (GRC) consultant.

Rajab Suliman is an assistant lecturer in the Department of Information Operations and Technology Management (IOTM) in the College of Business and Innovation (COBI) at the University of Toledo. His research interests include business analytics, modeling and optimization using response surface methodology (RSM), linear mixed model (longitudinal data analysis), experiment design, and regression analysis (linear and non-linear). Suliman also works with extended zero-one beta regression models to investigate the effect of covenant proximity on brain activity. Suliman holds a Ph.D. in computational science and statistics from South Dakota State University (2017).

Nasir Elmesmari is chair of the Department of Statistics at the University of Benghazi / Al Marj-Libya. His research interests include genome wide association (GWAS) in genetics, linear mixed model (threshold model) and logistic model, MCMC Gibbs algorithm for simulation, time series and modeling of linear models. Elmesmari earned a Ph.D. in computational science and statistics from South Dakota State University (2017) with a dissertation titled "Threshold Models for Genome-wide Association Mapping of Familial Breast Cancer Incidence in Humans"

Journal of the Midwest Association for Information Systems

Volume 2021 | Issue 2 Article 3

Date: 07-31-2021

Using Prototyping to Teach the Design Thinking Process in an Asynchronous Online Course

Mary C. Lebens
Metropolitan State University, mary.lebens@metrostate.edu

Abstract

Companies who use design thinking increase revenues and shareholder returns at almost double the rate of their industry peers, yet over 90% of companies do not employ design thinking, due to a lack of design skills in the workforce. Educators can address this skills gap by adding design thinking to the curriculum. Design thinking is a process where developers and users physically collaborate together to develop new products, so discovering whether online students who are never physically present together can successfully learn design thinking is critical to developing curriculum. This study examines whether students in "asynchronous online" courses can successfully apply design thinking to develop a prototype, as well as provide substantial feedback on classmates' prototypes during an iterative review process. The study employed an iterative model for the prototype design, review, and assessment. The results demonstrate that over two semesters an average of 77% of students successfully developed prototypes employing design thinking standards and 94% effectively provided feedback to peers on their prototypes during an iterative review process. The implication is faculty can confidently teach prototyping as a part of the design thinking process in asynchronous online courses, thereby helping to address the design thinking skills gap in the workforce.

Keywords: Design thinking, prototyping, iterative review, asynchronous online courses

DOI: 10.17705/3jmwa.000069

1. Introduction

Design thinking is an iterative process for creating prototypes of new products, gathering feedback from customers, and then redesigning the prototypes (Razzouk & Shute, 2012). The design thinking process and prototyping are effective business practices for developing new products because the product developers and customers work closely together, ensuring that the products meet the customers' needs (Dorst, 2011). Developing products that better meet customers' needs increases sales (Sheppard et al., 2018). Recent studies show companies using the design thinking process increase revenues and shareholder returns at almost double the rate of their industry peers, yet more than 90% of companies do not employ design thinking, because design thinking skills are largely missing from the workforce (Dalrymple et al., 2020; Sheppard et al., 2018). An example of how design thinking can improve revenues is IBM's implementation of the design thinking process for product development, which allowed IBM to cut costs by $20.6 million by accelerating projects and to increase portfolio profitability by $18.6 million by reducing risk (Brown, 2018). Design thinking increases revenue by improving customer experiences and by increasing product innovation (Gruber et al., 2015; Kolko, 2015; Mahmoud-Jouini et al., 2016).

Although design thinking skills are in demand, universities are still in a nascent stage of adding the design thinking process to the curriculum, and the majority have yet to even begin teaching it. A 2019 study of 99 business programs found two-thirds of universities have not started teaching design thinking using prototyping (Lande & Leifer, 2009; Razzouk & Shute, 2012; Sarooghi et al., 2019). At the same time more schools are offering online courses, with nearly all U.S. schools transitioning to online learning since the onset of the COVID-19 pandemic, but experts have long held that the iterative review employed by design thinking requires face-to-face communication (Garris & Fleck, 2020; Mishra et al., 2020; Turk et al., 2002; Williams, 2012).

This study examines whether students in an online asynchronous course can successfully apply the design thinking process through prototyping without ever being physically present together. Additionally, this study investigates whether students in an asynchronous online course can successfully complete an iterative review to provide feedback to their peers on their prototypes. The goal of this study is to determine whether faculty can feel confident employing the concepts of design thinking, including the practice of prototyping, in asynchronous online courses. If it is possible to teach the design thinking process successfully in asynchronous online courses, faculty in online programs can add design thinking to the curriculum, ultimately helping to address the shortage of design thinking skills in the workforce.

This paper begins with an overview of the related work, which supports the rationale for the study and the development of the research questions. After the presentation of the research questions, a description is provided of the course context and the course modifications that were made to add the design thinking process. The requirements for the prototype are defined, along with the International Organization for Standardization (ISO) guidelines that were used to judge whether the students' prototypes employed the standards of design thinking. Then the methodology is described, including the framework for implementing the design thinking process in the course and the rubric instrument used to measure whether students' prototypes met the standards for design thinking. Next the results of the study are presented and discussed in terms of how the findings supported the research questions. Finally, the conclusions and implications for the field of business are presented.

2. Related Work

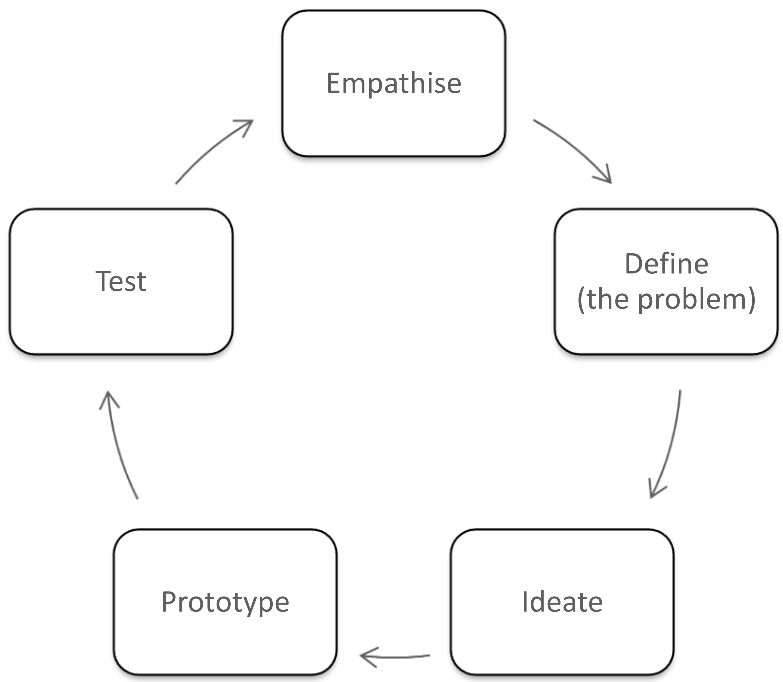
Stages in the Design Thinking Process

Design thinking is a process used in business and Information Technology (IT) to create products which solve specific problems (Dorst, 2011). As shown in Figure 1, the Hasso-Plattner Institute of Design at Stanford defines five stages in the process of design thinking: empathize, design, ideate, prototype, and test (Dam & Siang, 2021). During the first stage of design thinking, the developer is gaining an empathetic understanding of the problem by learning about it, which they then use to define the problem in the second stage of design thinking (Black et al., 2019). In the third stage of design thinking, the developer generates ideas about how to solve the problem (Dam & Siang, 2021). Then the developer models the solution to the problem using a prototype in the fourth stage (Dam & Siang, 2021). A prototype is a mockup of a new product that allows the user to interact with the product (Black et al., 2019).

Finally, in the last stage of the design thinking process, the developer presents the prototype to the user, and the user tests the prototype and provides feedback on how to improve it (Black et al., 2019). Prototyping allows the design team to create a visual mockup of the product to elicit feedback from the users, which the team then incorporates into the product design as a part of an iterative design process (Newman et al., 2015).The prototypes created during the design thinking process employ the standards of user-centered design, meaning that the product is developed with the users' needs in mind (Hartmann et al., 2006). The standards of user-centered design are defined by the ISO standard 9241-210:2019 Ergonomics of human-system interaction — Part 210: Human-centered design for interactive systems (ISO, 2019).

Figure 1

The Five Stages of the Design Thinking Process



Stages of the Systems Development Life Cycle (SDLC) and the Design Thinking Process

Table 1 shows how the stages of the design thinking process map to the phases of the SDLC. Stage 1 of the design thinking process maps to phase 1 of the SDLC, since this step involves observing, engaging with, and listening to users to understand their needs for the new product or system (Ragunath et al., 2010; Shanks, 2020). Stage 2 of the design thinking process roughly maps to phase 2 of the SDLC, since stage 2 involves defining the challenge or problem in design thinking, while phase 2 involves defining how the system will solve the problem, as well as defining the feasibility of the proposed system (Ragunath et al., 2010; Shanks, 2020). In the third stage of the design thinking process, ideation, the developer moves from identifying the problem to designing the solution, which maps to phase 3 of the SDLC, which is the design phase of the SDLC (Ragunath et al., 2010; Shanks, 2020).

During the fourth stage of the design thinking process, prototyping, the developer creates the prototype for the user to evaluate (Shanks, 2020). Stage 4 of the design thinking process approximately maps to the fourth phase of the SDLC. However, while the developer is creating a prototype in stage 4 of the design thinking process, they are coding the actual finished system in phase 4 of the SDLC (Ragunath et al., 2010). This is the point at which the design thinking process and the SDLC begin to diverge, as the waterfall nature of the SDLC means that the user does not interact with the system until it is finished, whereas the Agile approach of design thinking uses prototyping to elicit feedback from the user in an iterative fashion before the finished system is developed (Lichtenthaler, 2020).

Stage 5 of the design thinking process maps to phase 5 of the SDLC, since both involve testing (Ragunath et al., 2010; Shanks, 2020). However, stage 5 in design thinking consists of testing the prototype with the users, whereas phase 5 in the SDLC includes testing the finished system (Lichtenthaler, 2020; Shanks, 2020). There are no stages of the design thinking process which map to phases 6 and 7 of the SDLC, since the end product of the design thinking process is a prototype, not a finished system which requires installation, deployment, and maintenance (Ragunath et al., 2010; Shanks, 2020).

Table 1
Mapping the Stages of Design Thinking to the Phases of the Systems Development Life Cycle

Design Thinking	Systems Development Life Cycle
Stage 1: Emphasize	Phase 1: Requirement collection and analysis
Stage 2: Define	Phase 2: Feasibility study
Stage 3: Ideate	Phase 3: Design
Stage 4: Prototype	Phase 4: Coding
Stage 5: Test	Phase 5: Testing
No stage	Phase 6: Installation/Deployment
No stage	Phase 7: Maintenance

Rationale for Adding Design Thinking to the Curriculum

Design thinking has grown in popularity over the past two decades as method for incorporating the needs of users into products (Newman et al., 2015; Razzouk & Shute, 2012). However, educators are still in the beginning stages of adding design thinking concepts to technology-based degree programs, and the majority of programs do not yet incorporate design-thinking (Dym et al., 2005; Glen et al., 2014). Although prototyping is integral to the design thinking process, a 2019 survey of 99 business degree programs found only a third were currently using prototyping to teach design thinking (Sarooghi et al., 2019).

The rationale for integrating design thinking into the curriculum is that not only is it an in-demand skill, design thinking also provides students with myriad benefits, such as developing innovation, creativity, and emotional regulation (Dunne & Martin, 2006; Glen et al., 2015; Nielsen & Stovang, 2015). Integrating the design thinking process into the curriculum benefits students by increasing student learning, collaboration, and emotional development (Gerber & Carroll, 2012; Lande & Leifer, 2009; Rauth et al., 2010). The literature shows that although teaching design thinking using prototyping is a relatively new addition to the curriculum, it benefits students in a wide variety of ways (Huq & Gilbert, 2017; Kremel & Edman, 2019).

Employers increasingly expect graduates in technical fields to possess strong soft skills, which include innovation, creativity, and emotional regulation (Akman & Turhan, 2018; Wikle & Fagin, 2015). Integrating the design thinking process into the curriculum helps students develop the soft skills necessary to maneuver the innovation process, such as coping with ambiguity, and generating new ideas (Glen et al., 2015). Design thinking projects foster students' creativity and innovation because they encourage students to focus on "what might be?" in order to generate new solutions instead of narrowly focusing on a linear path to solving a fixed problem (Nielsen & Stovang, 2015). Students stretch their creativity during the design thinking process by generating new ideas for solving problems instead of relying on traditional business-school theories and models (Dunne & Martin, 2006).

Student learning increases when prototyping is integrated into college courses as a part of the design thinking process (Gerber & Carroll, 2012). A year-long Stanford University study on using prototyping to design products in an engineering course found students reported that they learned more and "worked better" when employing prototyping for their projects (Lande & Leifer, 2009). Professors in a research study conducted jointly at Stanford University and Potsdam University reported design thinking helped students develop prototyping skills as well as emotional skills, such as empathy (Rauth et al., 2010). A longitudinal study of 392 students in entrepreneurship courses at the Royal Melbourne Institute of Technology (RMIT) University in Australia showed teaching design thinking can significantly improve students' learning outcomes and experiences (Huq & Gilbert, 2017). Students in the RMIT study reflected positively on their experience with design thinking, commenting on how the learning environment is "highly interactive" and "more real" (Huq & Gilbert, 2017, p. 164). A 2020 study which introduced design thinking into an entrepreneurship course at Örebro University School of Business in Sweden discovered that design thinking increased student learning (Kremel & Edman, 2019). Students in this study showed a "high engagement in the learning process" (Kremel & Edman, 2019, p. 172). These findings demonstrate the benefits of teaching prototyping as a part of the design thinking process.

Adding Design Thinking to Asynchronous Online Courses

While the benefits to adding the design thinking process to the curriculum are clear, there are challenges with adding design thinking to college programs which contain courses offered in an asynchronous online format. In asynchronous online courses, there are no class sessions, so not only are students never present in the classroom physically together, and they are not even present online together. Since previous research on design thinking focuses on face-to-face courses, it is unknown whether students can use the Learning Management System (LMS) to successfully collaborate during the design thinking process the same way that designers and users typically interact face-to-face during the design thinking process (Huq & Gilbert, 2017; Kremel & Edman, 2019). The limitation of not being physically present together to share feedback on prototypes has the potential to hamper the process of using prototyping to learn design thinking skills, because prototyping is dependent on positive collaboration (Lachman & Rahnama, 2018). Since design thinking emphasizes the user and developer physically working together during the prototyping process, it is unclear if students who are unable to collaborate in real-time would be able to successfully develop prototypes using design thinking standards (Dantas de Figueiredo, 2021).

3. Rationale for Study

This study examines whether students in an asynchronous online undergraduate systems analysis and design course can use the design thinking process to successfully develop a system prototype and apply the standards of user-centered design to their prototype. The "asynchronous online" designation means that there are no class meetings and students are working on the course at any time of their choosing, 24 hours a day, seven days a week. The goals of the study are to determine if students are able to apply the process of design thinking through prototyping in this type of online course and to determine if students are able to provide substantive feedback to their peers on their prototypes while participating in an iterative review process. Most research on iterative development emphasizes that developers and users must physically work together, so it is significant to learn whether online students who are never physically present together in the classroom can successfully complete an iterative review as a part of the design thinking process (Turk et al. 2002; Williams 2012). The study was started prior to the onset of the COVID-19 pandemic in 2020, so there is also the opportunity to compare the results of prototyping using the design thinking process in sections of the course that were held pre-pandemic and post-pandemic.

Research Questions

R1: Are students in an asynchronous online undergraduate systems analysis and design course able to successfully develop a system prototype?

R2: Are students in an asynchronous online undergraduate systems analysis and design course able to successfully apply the standards of design thinking to a system prototype?

R3: Are students in an asynchronous online undergraduate systems analysis and design course able to participate in the iterative prototype review process to provide substantial feedback to their classmates to help them to improve their web prototypes?

R4: Are there differences in the results for developing prototypes using design thinking between the pre-pandemic and post-pandemic course sections?

4. Course Context

Background on Course Project

Students in the systems analysis course complete a substantial project based on an information systems business case. The project is individual, not team based. The project's goal is modeling the information system described in the case using the design thinking process to develop a prototype. Students choose their own business cases. However, the case is subject to the approval of the professor to ensure that the chosen case includes an information system which can easily be modeled by a prototype as a part of the project. The professor provides a list of solid sources for cases, such as journals and software vendor sites which contain appropriate information systems cases.

Revisions to the Course Project

The course project was substantially revised for this study to include the design thinking process, so that students would have the opportunity to apply the design thinking concepts that they studied in the course materials to a prototype of the system. Previously the project required students to model a system using several types of diagrams, including Entity-Relationship Diagrams (ERDs) and use case diagrams. The appendix includes the instructions and the rubric used for grading the original version of the project. The revised project also included diagramming the system using ERDs and use cases in the project proposal, since diagramming is a key learning outcome for the course. However, the revised project was significantly expanded on the original by adding a new outcome. In addition to diagramming the system, the revised project requires students to use the design thinking process to develop a web prototype of the system. A detailed description of the revised project is included in the appendix, along with the instructions for the revised project. In addition, the timeline for the project along with a detailed task list is provided in the appendix.

Student Progress through the Design Thinking Process During the Course Project

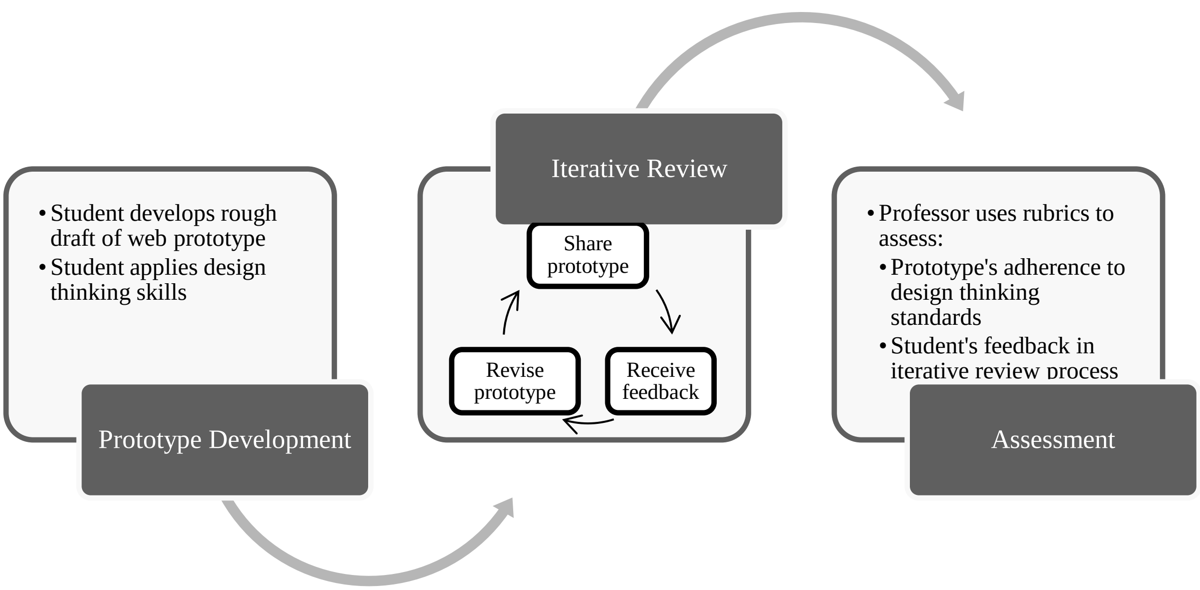
Students prepared for the course project by reading articles on the design thinking process, completing an online learning module on the stages in the design thinking process, and taking an interactive online quiz to test their knowledge of design thinking concepts. After the project kickoff, students engaged in the first three stages of the design thinking process (empathize, define, and ideate) by gathering observations on the system to emphasize with the user, defining the problem to be solved by improving the information system, and by generating ideas on how to solve the problem. The students researched the system in the case using vendor documentation, white papers, and technical articles to gather their observations on the system. Then students documented their observations, the problem definition, and their ideas on how to solve the problem in a project proposal. After writing the project proposal, students entered the fourth stage of the design thinking process: prototyping. The process modeled in Figure 2 was employed for developing, reviewing, and assessing the prototypes.

After developing prototypes, students entered the fifth and final stage of the design thinking process: testing the prototype. The students participated in an iterative review process to test the prototypes and give feedback on them, as modeled in Figure 2. Each student was assigned two classmates and provided feedback on those two classmates' prototypes, to ensure every student received feedback from their peers.

The students provided feedback using the feedback form shown in the appendix in Figure 4. The feedback form was based on the grading rubric for the web prototype as well as the standards of user-centered design, based on the ISO standard 9241-210:2019 (ISO, 2019). As students were evaluating the web prototypes, they were encouraged to refer to the standards for user-centered design as well as reflect on the reading on design thinking which had been previously assigned. The quality of the feedback that students provided to their peers was evaluated using a rubric, which is shown in Table 3 in the Procedure subsection of the Methodology section.

Figure 2

Model for Prototype Development, Iterative Review, and Assessment Process



Choosing a Development Platform for Prototyping

Students used the "Weebly" web development platform for creating the prototype of the system in their case. This platform was chosen based on four criteria which were established to ensure the development environment was appropriate for beginning students and to ensure equity by allowing all students to participate in the prototyping process regardless of income level or type of computer used at home. Weebly was selected as the web development platform because it met all four criteria. The criteria for determining the development platform included:

- Support for browser-based and cloud-based development.
- Free or low-cost pricing.
- Low-code/no-code environment.
- Reputation as a website provider.

While all of the students in the course are upper-division students enrolled in the Information Systems (IS) program, and IS students are required to have access to a computer to complete their coursework, the students' computers may have Windows or Mac OS, so using a browser-based, OS-independent platform was important. If students are unable to purchase a computer due to the cost, the school provides loaner PCs. Students who reside in a low-income household can also receive a free computer through a local non-profit which partners with the school. All students have internet access with reasonable speed and bandwidth, as the school provides hotspots to online students who are unable to come to campus to use the school Wi-Fi. Weebly is a low-bandwidth application and tolerates poor connectivity well. Since it auto-saves while the student is working and automatically reconnects, students will not lose work due to a spotty internet connection.

Prototype Requirements

As a part of the course project, the students were not only required to create a prototype of the system described in their case, they were also required to meet specific requirements to ensure they were applying design thinking standards. The prototype needed to employ the standards of user-centered design, based on the ISO standard 9241-210:2019 (ISO, 2019). There are five standards which are embodied by this standard:

1. The design is based on a clear comprehension of users, tasks, and environments.
2. Both the design and development involve users.
3. User-centered evaluation is employed to revise the design.
4. The design process is iterative.
5. The design addresses the entirety of the user experience.

Prior to embarking on the web prototype of the system, students met the first and fifth sub-standards in the ISO 9241-210 standard by creating a development proposal for the information system. To ensure students had a clear understanding of the users, tasks, and environments for the system, as well as a design that addressed the entirety of the user experience, students created the following artifacts as a part of their proposal:

- A list of the stakeholders and actors for the system.
- A list of the major use cases for the system.
- A diagram of the use case that is most critical to the functioning of the system.

Students met the second, third, and fourth sub-standards in the ISO 9241-210 standard by following an iterative review process. Since the actual users of the information system were not available for the project, students posed as users to test the web prototypes of their fellow classmates and then provide substantial feedback on the web prototypes. The Learning Management System (LMS) was used to facilitate the review process. The student developers followed an iterative process to use this feedback to revise the web prototypes and improve the usability of the web design.

5. Methodology

The course project included applying the design thinking process using prototyping. This project was used in two sections of an undergraduate systems analysis course at a public university in the upper Midwest area of the United States. The two asynchronous online course sections were held over summer semester 2019 and summer semester 2020. The semesters were a standard 15-week length.

Participants

A total of 41 students participated in the two course sections. The students were upper-division undergraduates who were Management Information Systems (MIS) majors. The students were roughly split between those identifying as females and those identifying as males. The university is a Federally designated minority serving institution, serving primarily non-traditional students with an average age of 29 years old.

Procedure

The project was implemented as an individual student project, so each student developed their own prototype. This was not implemented as a team project. However, students collaborated after developing their prototypes to give feedback to each other on the prototypes. After students developed their web prototypes, the students posted the links to their prototypes in the Learning Management System (LMS) to share them with their classmates. Then each student reviewed two of their classmates' prototypes and provided substantial feedback using a worksheet based on the rubric used to grade the prototype. The process modeled in Figure 2 was employed for developing, reviewing, and assessing the prototypes. The students' success in completing the web prototype portion of the project and employing the standards of user-centered design in their prototype was measured using the rubric shown in Table 2. After developing prototypes, students participated in an iterative review process, as modeled in Figure

2. Students' completion of the prototype review process and feedback to their classmates was measured using the rubric shown in Table 3.

In order to measure student performance on the prototyping discrete from other parts of the project, separate rubrics were used to evaluate the prototyping and iterative review process, as shown in Tables 2 and 3. Instead of using a traditional letter grade to evaluate the prototyping portion of the project, students were evaluated on how well their prototype met the standards of user-centered design, demonstrating that they applied the process of design thinking they learned in the course materials.

Table 2

Rubric for Web Prototype

Criterion	Professional Level	Amateur Level	Unsatisfactory Level
	The user interface for the web prototype was appropriate for the system, based on the description of the system given in the project proposal.	The user interface for the web prototype was mostly appropriate for the system, based on the description of the system given in the project proposal. One to two elements were missing or did not fit with the description in the proposal.	The web prototype was not uploaded to the dropbox by the due date or user interface for the web prototype was not appropriate for the system, based on the description of the system given in the project proposal. Multiple elements were missing or did not fit with the description in the proposal.
User-Centered Design	The web prototype employed the standards of user-centered design.	The web prototype mostly employed the standards of user-centered design. One or two elements were not user-friendly.	The link to the web prototype was not posted to the dropbox by the due date or the web prototype did not employ the standards of user-centered design. Multiple elements were not user-friendly.
Link Uploaded Correctly	The link to the web prototype was uploaded to the dropbox by the due date and the link worked correctly to open the website.	The link to the web prototype was uploaded to the dropbox after the due date and the link worked correctly to open the website.	The link to the web prototype was not uploaded to the dropbox by the due date and/or the link did not work correctly to open the website.

The students were graded on the feedback they provided on their classmates' web prototypes using a rubric, as shown in Table 3. This rubric provided an objective assessment of how well the students met the requirement for providing feedback which could be used to improve the prototype.

Table 3

Rubric for Feedback on Web Prototype

Criterion	Sufficient Feedback	Insufficient Feedback
Submitted feedback to the group discussion area prior to the deadline on the course schedule.	Feedback to the group discussion area submitted prior to the deadline.	Feedback to the group discussion area was submitted after the deadline.
Provided meaningful feedback on organization and clarity of points in assignment.	Comments include specific suggestions improving structure and order.	Comments do not include specific suggestions for improving structure and order.
Provided all comments in a positive, encouraging, and constructive manner.	Comments praise specific strengths of the presentation as well as constructively addressing weaknesses with alternatives that might be considered.	Comments might be interpreted as insulting.

6. Results

Students whose prototypes met all five sub-standards scored a level of professional, students whose prototypes met three to four of the sub-standards scored a level of amateur, and students whose prototypes met two to none of the standards scored a level of unsatisfactory. 100% of the students in both sections completed the prototype. As shown in Table 4, across the two sections over 78% of the students scored at the professional level and over 21% scored at the amateur level, meaning the majority of students employed all five standards of user-centered design in their prototypes. This finding indicates that the answer to research questions R1 and R2 is yes, since 100% of the students were able to successfully develop a system prototype, and over 78% of the students were able to successfully apply all five of the sub-standards of user-centered design to their prototype.

Table 4

Student Scores on "User-Centered Design" Criterion in Web Prototype Rubric

Semester	Professional Level	Amateur Level	Unsatisfactory Level	Percent of Students Meeting Professional Level
Summer 2019	12	5	0	70.58%
Summer 2020	21	4	0	84.00%
Total	33	9	0	78.57%

As shown in Table 5, of the nine students who scored amateur and did not meet all five of the design sub-standards, seven of them missed meeting only a single sub-standard, and that was sub-standard 1: "The design is based on a clear comprehension of users, tasks, and environments." The seven students who failed to meet this standard did not design a prototype which incorporated the system users, user tasks, and the system environment that was described in their project proposal. The two remaining students who scored amateur missed meeting two standards, standard 1 and standard 5: "The design addresses the entirety of the user experience." Both of these students created prototypes which failed to incorporate the system users, user tasks, and system environment, as well as did not address the entire user experience. One of these two prototypes failed to address the entire user experience because the web prototype was for an online store, yet it lacked a way for the user to check out and pay for their purchase. The other prototype that failed to address the entire user experience was developed for a manufacturing system, yet the inventory management web page was blank, meaning that users could not monitor the inventory of the raw production materials used to manufacture products.

As shown in Table 5, 100% of the students met the second, third, and fourth sub-standards for the development of the web prototypes. All of the web prototypes met sub-standard 2 by including user needs in the design. All of the student prototypes employed user-centered evaluation to revise the design and employed an iterative design process, as described in standards 3 and 4. Even the nine students that scored an amateur level, and were unsuccessful at meeting all of the user-centered standards, still incorporated the feedback provided by classmates to improve the prototype to some extent between the rough draft and the final draft. For example, the manufacturing system prototype that lacked the inventory page in the final draft had also been lacking other functionality in the rough draft which the student added based on feedback from their classmates. Since 100% of the students were successful at incorporating feedback from classmates on their prototypes, this supports an answer of "yes" to research question R3. Students were able to participate in the iterative prototype review process and provide substantial feedback to their classmates to help them to improve their web prototypes.

Table 5

Number of Students Who Did Not Meet Each of the User-Centered Design Sub-Standards

Semester	Sub-Standard 1	Sub-Standard 2	Sub-Standard 3	Sub-Standard 4	Sub-Standard 5
Summer 2019	5	0	0	0	2
Summer 2020	4	0	0	0	0
Total	9	0	0	0	2

During summer semester 2019, 17 students successfully completed the course. As shown in Table 6, of the 17 students who completed the course, 100% of them completed the web prototype portion of the project. This finding supports an answer of "yes" to research question R1 by demonstrating that students in an asynchronous online undergraduate systems analysis and design course are able to successfully develop a system prototype. Table 6 shows the percent of students who employed the user-centered design sub-standards, which includes students who met the professional level and excludes the students who met the amateur level. No students were at the unsatisfactory level, meaning none of the students met only zero to two of the sub-standards, failed to submit a prototype, or submitted a prototype past the due date listed on the course schedule.

As shown in Table 6, over 70% of students in the 2019 section successfully applied the sub-standards of user-centered design in their prototypes. No students were at the unsatisfactory level. This finding supports an answer of "yes" to research question R2 by demonstrating that the majority of students in an asynchronous online undergraduate systems analysis and design course were able to successfully apply the standards of user-centered design to a system prototype. Of the students who completed the course in the 2019 section, over 94% participated in the iterative prototype review process, and over 88% provided substantial feedback to their classmates to help them to improve their web prototypes, as shown in Table 7. This finding indicated that the answer to research question R3 is “yes” by showing that students in an asynchronous online undergraduate systems analysis and design course were able to participate in the iterative prototype review process to provide substantial feedback to their classmates to help them to improve their web prototypes.

During summer semester 2020, 25 students completed the course. 100% of the students who completed the course successfully completed the web prototype portion of the project, and 84% successfully applied the standards of design thinking to their prototypes, as shown in Table 6. This result provides support for an answer of “yes” for research questions R1 and R2 by demonstrating that students in an asynchronous online undergraduate systems analysis and design course are able to successfully develop a system prototype and to apply the standards of design thinking to the system prototype. Additionally, 100% of the students in the summer 2020 section participated in the iterative prototype review process and provided substantial feedback to their peers during the review process, as shown in Table 7. This finding indicates that the answer to research question R3 is “yes” by showing students in an asynchronous online undergraduate systems analysis and design course were able to participate in the iterative prototype review process to provide substantial feedback to their classmates to help them to improve their web prototypes.

Table 6

Completion of Prototypes which Employed User-Centered Design

Semester	Completed Course	Completed Prototype	Percent Prototype Completion	Employed User-Centered Design	Percent Employed User-Centered Design
Summer 2019	17	17	100%	12	70.58%
Summer 2020	25	25	100%	21	84.00%
Total	42	42	100%	33	77.29%

Table 7

Completion of Iterative Review and Providing Sufficient Feedback

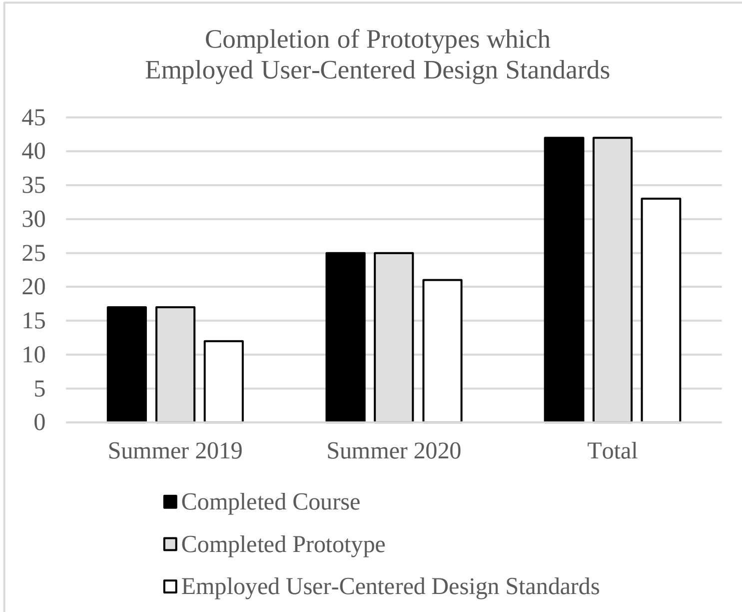
Semester	Completed Course	Completed Iterative Review	Percent Completed Iterative Review	Provided Sufficient Feedback	Percent Provided Sufficient Feedback
Summer 2019	17	16	94.11%	15	88.23%
Summer 2020	25	25	100%	25	100%
Total	42	41	97.06%	40	94.16%

Comparison of Summer Semester 2019 to Summer Semester 2020

Figure 3 compares the number of students who successfully completed the course, completed the prototype, and employed user-centered design standards during summer 2019 and summer 2020. Both course sections began with an initial enrollment of 27 students, but significantly more students completed the course during the summer 2020 semester than the summer 2019 semester. Only 17 students completed the course in 2019 versus 25 students in 2020. Additionally, more students in the 2020 section completed the prototype and employed user-centered design standards. These indicate an answer of “yes” to research question R4 by demonstrating that there were differences in the results for developing prototypes using design thinking between the pre-pandemic and post-pandemic course sections.

Figure 3

Completion of Prototypes which Employed User-Centered Design Standards



7. Discussion

In both sections of the systems analysis course, the majority of students demonstrated that they could employ the design thinking process in their projects. The vast majority of students completed the web prototype and successfully employed the standards of user-centered design in their prototype. The findings of this study demonstrate that the answers to research questions R1 and R2 are both yes, since students in the asynchronous online undergraduate systems analysis and design course were able to successfully develop a system prototype and to successfully apply the standards of design thinking to the system prototype. This is an extremely encouraging finding because it shows prototyping is a viable approach to applying the design thinking process in an asynchronous online course, despite the literature showing that face-to-face interaction between the user and the designer is required for the prototyping stage of the design thinking process.

In addition, all of the students in the 2020 section and all but one of the students in the 2019 section successfully performed as users during the iterative review process to provide substantial feedback to their peers on their prototypes. This finding shows that the answer to research question R3 is yes, since the vast majority of students in the asynchronous online undergraduate systems analysis and design course were able to participate in the iterative prototype review process to provide substantial feedback to their classmates to help them to improve their web prototypes. This is also an exceptionally encouraging finding, since most research on design thinking emphasizes that developers and users must physically work together during the prototyping stage of the design thinking process (Turk et al., 2002; Williams, 2012). Since the students in this online course could not even synchronously work together, much less physically work together, this finding provides great optimism that remote student teams can be successful in using an iterative approach for developing prototypes. Additionally, the students' high level of performance on providing substantive feedback and using it to improve their prototypes demonstrated that they gained benefits from the inclusion of the design thinking process into the curriculum, such as learning to refine the solution to the problem they identified.

An unexpected finding in this study was that not only were students able to apply the design thinking process through prototyping in an asynchronous online environment, the students in the 2020 section actually performed better at this task, despite the stressors wrought over the summer of 2020 by the COVID-19 pandemic and the civil unrest following George Floyd's murder in Minneapolis, MN, where the University is located (Hughes, 2020; Parks, 2020). This finding demonstrates that the answer to research question R4 is yes, since there were differences in the results for developing prototypes using design thinking between the pre-pandemic and post-pandemic course sections. This is thought-provoking because it seems counter-intuitive that students would be more successful at applying a challenging concept such as design thinking during a semester with extreme stressors outside the classroom. The students' high level of performance is especially surprising since a study by the American College

Health Association found college students were significantly stressed due to the COVID-19 pandemic in May 2020 when the summer semester started (The Healthy Minds Network and the American College Health Association, 2020). The same professor taught both sections using the same project instructions, course materials, and mode of delivery, so it is unknown why the summer 2020 cohort performed better at applying the concepts of design thinking through prototyping than the summer 2019 cohort. Although the systems analysis course which was the subject of this study is always taught in an online format, prior to the pandemic, students in the program could choose to register for face-to-face sections for several of the other courses in their major. Perhaps the students had more comfort in the online environment during 2020, because all of their courses were in an online format and their skills in the online learning environment improved as a result.

The results of this research demonstrate that faculty can confidently use the design thinking process, including the practice of prototyping, in asynchronous online courses to teach students design thinking skills. The wider implication is that providing evidence of student success in prototyping and the design thinking process will encourage faculty to implement these high-demand skills, thereby closing the skills gap. Since companies which employ the design thinking process increase revenue and shareholder returns at almost double the rate of their industry peers, closing the skills gap for design thinking will have a positive impact on the growth of organizations (Dalrymple et al., 2020; Sheppard et al., 2018).

Limitations and Further Research

A key limitation of this study was the sample size of 41 students. Since the study was designed to minimize course delivery variables by using the same course and professor, the population was limited to two course sections. Another limitation was student data prior to revising the course project was not available due to faculty turnover in the University, limiting comparison between the previous course project and revised course project in terms of student performance. This research will be continued with future sections to create a lengthier longitudinal study, providing a longer-term set of results as well as a larger sample size. An additional limitation of this study was the presence of the pandemic during the second section of the course, which may have inadvertently impacted student results due to the wide-ranging social effects of COVID-19. Further research is needed to show how students perform at using prototyping as a part of the design thinking process after the pandemic wanes. A limitation was created by the way in which the University scheduled this course, as the course is routinely scheduled in an asynchronous online format, so there is no data from a face-to-face section of the course to use as a comparison.

Further research is needed to compare the success of students in the asynchronous online course with students in other course formats, such as synchronous online courses with web-based class sessions and face-to-face course sessions. In addition, future research could be done on students' perceptions of using prototyping by incorporating an individual reflection on the design thinking process or by conducting class evaluations.

8. Conclusion

As the design thinking process and the accompanying practice of prototyping have become more commonplace in business, universities are slow at implementing these concepts in courses to prepare students for the workplace (Lande & Leifer, 2009; Sarooghi et al., 2019). This study demonstrates that students in an online asynchronous course can successfully apply the design thinking process, including prototyping. This finding is exceptionally promising since it shows prototyping is a viable approach to applying the design thinking process in an asynchronous online course. Additionally, this study establishes that students in an asynchronous online course can successfully complete an iterative review to provide feedback to their peers on their prototypes, despite never sharing a classroom with their peers. This finding is extremely encouraging, since the predominant view is that the iterative portion of the design thinking process must involve face-to-face communication (Turk et al., 2002; Williams, 2012). This study demonstrates that faculty can feel confident employing the design thinking process, including the practice of prototyping, in asynchronous online courses to teach their students the valuable 21st century skill of design thinking. The broader impact is that providing evidence of student success in prototyping and design thinking will inspire faculty to employ these two high-demand skills, thereby closing the skills gap and helping companies utilize design thinking to dramatically increase revenue and shareholder returns.

9. References

Akman, I., & Turhan, C. (2018). Investigation of employers' performance expectations for new IT graduates in individual and team work settings for software development. *Information Technology & People*, *31*(1), 199–214. http://dx.doi.org.mtrproxy.mnpals.net/10.1108/ITP-01-2017-0020

Black, S., Gardner, D. G., Pierce, J. L., & Steers, R. (2019). Design Thinking. In *Organizational Behavior*. OpenStax, BCcampus Open Publishing.

Brown, B. (2018). *The Total Economic Impact™ Of IBM's Design Thinking Practice* (pp. 1–45). Forrester.

Dalrymple, M., Pickover, S., & Sheppard, B. (2020). *Are You Asking Enough from Your Design Leaders?* (McKinsey Quarterly, pp. 1–19). McKinsey & Company. https://www.mckinsey.com/business-functions/mckinsey-design/our-insights/are-you-asking-enough-from-your-design-leaders

Dam, R. F., & Siang, T. Y. (2021). *5 Stages in the Design Thinking Process*. Interaction Design Foundation. https://www.interaction-design.org/literature/article/5-stages-in-the-design-thinking-process

Dantas de Figueiredo, M. (2021). Design is cool, but … A critical appraisal of design thinking in management education. *The International Journal of Management Education*, *19*(1), 1–8. https://doi.org/10.1016/j.ijme.2020.100429

Dorst, K. (2011). The core of 'design thinking' and its application. *Design Studies*, *32*(6), 521–532. https://doi.org/10.1016/j.destud.2011.07.006

Dunne, D., & Martin, R. (2006). Design thinking and how it will change management education: An interview and discussion. *Academy of Management Learning & Education*, *5*(4), 512–523.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2005). Engineering Design Thinking, Teaching, and Learning. *Journal of Engineering Education*, *94*(1), 103–120. https://doi.org/10.1002/j.2168-9830.2005.tb00832.x

Garris, C. P., & Fleck, B. (2020). Student evaluations of transitioned-online courses during the COVID-19 pandemic. *Scholarship of Teaching and Learning in Psychology*, *6*(4), 1–21. https://doi.org/10.1037/stl0000229

Gerber, E., & Carroll, M. (2012). The psychological experience of prototyping. *Design Studies*, *33*(1), 64–84. https://doi.org/10.1016/j.destud.2011.06.005

Glen, R., Suciu, C., & Baughn, C. (2014). The need for design thinking in business schools. *Academy of Management Learning & Education*, *13*(4), 653–667. https://doi.org/10.5465/amle.2012.0308

Glen, R., Suciu, C., Baughn, C. C., & Anson, R. (2015). Teaching design thinking in business schools. *The International Journal of Management Education*, *13*(2), 182–192. https://doi.org/10.1016/j.ijme.2015.05.001

Gruber, M., De Leon, N., George, G., & Thompson, P. (2015). Managing by design. *Academy of Management Journal*, *58*(1), 1–7.

Hartmann, B., Klemmer, S. R., & Abdulla, M. B. L. (2006). Reflective physical prototyping through integrated design, test, and analysis. *Proceedings of the Association of Computing Machinery Symposium on User Interface Software and Technology (UIST)*, *ACM Digital Library*, 299–308.

Huq, A., & Gilbert, D. (2017). All the world's a stage: Transforming entrepreneurship education through design thinking. *Education & Training*, *59*(2), 155–170. http://dx.doi.org.mtrproxy.mnpals.net/10.1108/ET-12-2015-0111

ISO. (2019). *ISO 9241-210:2019 Ergonomics of human-system interaction—Part 210: Human-centred design for interactive systems* (13.80 Ergonomics; p. 33). ISO. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/07/75/77520.html

Kolko, J. (2015). Design thinking comes of age. *Harvard Business Review*, *93*(9), 66–71.

Kremel, A., & Edman, K. W. (2019). Implementing design thinking as didactic method in entrepreneurship education. *The Design Journal*, *22*(sup1), 163–175. https://doi.org/10.1080/14606925.2019.1595855

Lachman, R., & Rahnama, H. (2018). The supercourse: A case-study in collaboration, cross-disciplinarity, and mixed reality prototyping in higher education. *Journal of Higher Education Theory & Practice*, *18*(3), 135–144. https://doi.org/10.33423/jhetp.v18i3.567

Lande, M., & Leifer, L. J. (2009). Prototyping to learn: Characterizing engineering students' prototyping activities and prototypes. *Proceedings of the International Conference on Engineering Design*, *The Design Society*, 507–516.

Lichtenthaler, U. (2020). Agile Innovation: The Complementarity of Design Thinking and Lean Startup. *International Journal of Service Science, Management, Engineering, and Technology (IJSSMET)*, *11*(1), 157–167. https://doi.org/10.4018/IJSSMET.2020010110

Mahmoud-Jouini, S. B., Midler, C., & Silberzahn, P. (2016). Contributions of Design Thinking to Project Management in an Innovation Context. *Project Management Journal*, *47*(2), 144–156. https://doi.org/10.1002/pmj.21577

Mishra, L., Gupta, T., & Shree, A. (2020). Online teaching-learning in higher education during lockdown period of

COVID-19 pandemic. *International Journal of Educational Research Open*, *1*(2020), 1–8. https://doi.org/10.1016/j.ijedro.2020.100012

Newman, P., Ferrario, M. A., Simm, W., Forshaw, S., Friday, A., & Whittle, J. (2015). The Role of Design Thinking and Physical Prototyping in Social Software Engineering. *Proceedings of the 2015 IEEE/ACM 37th IEEE International Conference on Software Engineering*, *IEEE*, 487–496. https://doi.org/10.1109/ICSE.2015.181

Nielsen, S. L., & Stovang, P. (2015). DesUni: University entrepreneurship education through design thinking. *Education & Training*, *57*(8/9), 977–991. http://dx.doi.org.mtrproxy.mnpals.net/10.1108/ET-09-2014-0121

Ragunath, P., Velmourougan, S., Davachelvan, P., Kayalvizhi, S., & Ravimohan, R. (2010). Evolving a new model (SDLC model-2010) for software development lifecycle (SDLC). *International Journal of Computer Science and Network Security*, *10*(1), 112–119.

Rauth, I., Köppen, E., Jobst, B., & Meinel, C. (2010). Design thinking: An educational model towards creative confidence. *Proceedings from First International Conference on Design Creativity*, *ICDC*, 1–8.

Razzouk, R., & Shute, V. (2012). What is design thinking and why is it important? *Review of Educational Research*, *82*(3), 330–348. https://doi.org/10.3102/0034654312457429

Sarooghi, H., Sunny, S., Hornsby, J., & Fernhaber, S. (2019). Design thinking and entrepreneurship education: Where are we, and what are the possibilities? *Journal of Small Business Management*, *57*(1), 78–93. https://doi.org/10.1111/jsbm.12541

Shanks, M. (2020). *An introduction to design thinking: Process guide* (pp. 1–6). Hasso Plattner Institute of Design, Stanford University.

Sheppard, B., Sarrazin, H., Kouyoumijan, G., & Dore, F. (2018). *The Business Value of Design* (McKinsey Quarterly, pp. 1–16). McKinsey & Company. https://www.mckinsey.com/business-functions/mckinsey-design/our-insights/the-business-value-of-design

Turk, D., France, R., & Rumpe, B. (2002). Limitations of agile software processes. *Third International Conference on Extreme Programming and Flexible Processes in Software Engineering*, *XP2002*, 43–46.

Wikle, T. A., & Fagin, T. D. (2015). Hard and Soft Skills in Preparing GIS Professionals: Comparing Perceptions of Employers and Educators. *Transactions in GIS*, *19*(5), 641–652. https://doi.org/10.1111/tgis.12126

Williams, L. (2012). What agile teams think of agile principles. *Communications of the ACM*, *55*(4), 71–76. https://doi.org/10.1145/2133806.2133823

10. Appendix

Original Project Instructions

Part 1: Develop an Entity Relationship Diagram (ERD) to depict the key data entities relevant to the system you have chosen. You should reverse engineer the tables and relationships for the ERD using the data-entry screens in the system. Write two to three paragraphs describing why the entities you depicted in your ERD are the most important entities for this system.

Part 2: Create a use case diagram for your chosen system. Write a paragraph describing the use case diagram.

Part 3: Create a Swimlane diagram to depict the activities, conditions and overall flow of the system you have chosen.

Part 4: Develop one additional requirements model of your choice to depict a process in the system you have chosen. You can choose from the following types of models: State Machine diagram, Data Flow Diagram (DFD), or Sequence diagram. For each model, write a paragraph describing the system process depicted by the model. In addition, for each model, write a paragraph describing why you chose this particular model.

Part 5: Write an executive summary of 1-2 pages that will introduce your models and summarize the case you chose that describes the system.

Original Project Rubric

The project will be graded on a scale of 0% to 100% based on an evaluation of the following criteria:

- Completeness – Was the project complete and did it meet the requirements described in the project instructions? Were the requirements models logically consistent with each other? Were assumptions and questions stated for each model?
- Precision – Was the project document presented clearly? Were the diagrams clear and easy to understand? Were the supporting descriptions for the models written clearly?
- Promptness - Was the project submitted on time?

Modified Project Instructions

Project Overview

- The aim of the project is to allow you to plan a system and then develop a web-based prototype for the system which can be added to your portfolio. Each student will develop a web prototype that can be added to the student's independent portfolio.

Project Proposal

- You are a consultant for TekMaxim Solutions. You are trying to secure a six-figure contract to build the systems solution that is described in the case. Your task is to create a project proposal and prototype for the new system that is so stellar that the company will hire you to build the system.

Structure of Proposal

1. Executive Summary
    - Describe the purpose of your system and the audience for your system. Imagine you are writing for top management, such as the CEO of your company. Be persuasive as to why this system is a worthwhile endeavor for your company to undertake.
2. Description of Users and Development Approach
    - Make a list of the users of the system.
    - Who will be using the system once it is implemented? Are all of the users described in the case? Are there potential users who are not mentioned in the case?
    - Recommend a development approach for the project, either using the traditional SDLC or an Agile methodology.
    - Justify why the approach you chose is optimal for this systems project.
3. System Requirements
    - Define the requirements for the system. What (in detail) do we need the system to do? Describe both the functional requirements for the system and the non-functional requirements (technical, performance, usability, reliability, and security requirements).
4. Budget and Cost-Benefits Analysis
    - Create a detailed budget for the project.
    - Use the budget to perform a cost-benefits analysis for the project. Calculate the Net Present Value (NPV) of the project as a part of your cost-benefits analysis.
5. Work Breakdown Structure (WBS)
    - Develop a detailed Work Breakdown Structure (WBS). Each task should be assigned a deadline.
    - Format your WBS like the one depicted in the textbook.

Modified Project Rubrics

The modified project rubrics were shown earlier in Tables 1 and 2. The rubrics were used to evaluate the prototyping and iterative review process, as shown in Table 1 and 2.

Feedback Form for Web Prototype

The feedback form that students used to evaluate their classmates' prototypes is shown in Figure 4 below.

Figure 4

Feedback Form for Web Prototype

Name of Reviewer: ___________________ Classmate Being Reviewed: _________________

Instructions:

1. Review your classmate's web prototype.
2. Answer the questions below to give written feedback to your classmate.
3. After answering the questions, circle the appropriate level for each criterion in the rubric. To circle the criterion in Word, click on the Insert tab, click on Shapes, and choose a circle, then select the circle and choose "no fill".
4. Upload the completed feedback form to share it with your classmate by the due date on the course schedule.

Background:

We will be using five standards of user-centered design to evaluate the web prototypes. These standards are a part of the broader of the ISO standard 9241-210:2019 "Ergonomics of human-system interaction — Part 210: Human-centered design for interactive systems".

Here are the five standards:

1. The design is based on a clear comprehension of users, tasks, and environments.
2. Both the design and development involve users.
3. User-centered evaluation is employed to revise the design.
4. The design process is iterative.
5. The design addresses the entirety of the user experience.

The questions below will prompt you to compare your classmate's web prototype to these standards. Please also refer to the previous reading on design thinking that was assigned. The links to the assigned articles are listed on the course schedule.

Questions:

1. Compare your classmate's web prototype to the project proposal that they previously uploaded. Does the web prototype address the needs of the system users that are described in the project proposal? Why or why not?
2. Does the web prototype allow the user to perform the tasks that are described in the project proposal? Why or why not? Which tasks (if any) are not supported by the prototype?
3. Does the prototype match the system environment that is described in the project proposal? What needs to be changed to make the prototype better fit with the system environment described in the proposal?
4. Are any of the design elements of the web prototype not user-friendly? (Refer to the articles that were previously assigned for reading on design thinking for examples of user-friendly design.) How can the design be improved to be more user-friendly?
5. Does the design of the prototype address the entirety of the user experience, as described in the proposal? If not, what can be changed to make sure the user's experience is better met by the web prototype of the system?

Rubric for Feedback:

Criterion	Professional Level	Amateur Level	Unsatisfactory Level
Web Prototype User Interface	The user interface for the web prototype was appropriate for the system, based on the description of the system given in the project proposal.	The user interface for the web prototype was mostly appropriate for the system, based on the description of the system given in the project proposal. One to two elements were missing or did not fit with the description in the proposal.	The web prototype was not uploaded to the dropbox by the due date or user interface for the web prototype was not appropriate for the system, based on the description of the system given in the project proposal. Multiple elements were missing or did not fit with the description in the proposal.
User-Centered Design	The web prototype employed the standards of user-centered design.	The web prototype mostly employed the standards of user-centered design. One or two elements were not user-friendly.	The link to the web prototype was not posted to the dropbox by the due date or the web prototype did not employ the standards of user-centered design. Multiple elements were not user-friendly.

Project Timeline

The course is structured as a 15-week course with 14 modules. The project is initiated during the second module and concludes in the fourteenth module, as shown in Table 8, so it spans around twelve weeks of the course. There may be a week of vacation (for 4th of July, spring break, or fall break) during the project, depending on the school calendar, which changes from year to year.

Table 8

Project Timeline

Module	Project Tasks
2	Project Kick-Off: Students choose the case for their project.
3	Students begin creating project proposal based on their case.
4	Students upload rough draft of project proposal to LMS.
5	Each student reviews a classmate’s proposal and uses the Track Changes feature in Word to add feedback to the proposal. The student uploads the revised proposal containing feedback to the LMS.
6	Students use the feedback from their classmates to revise their proposals and submit the final draft.
7	Students begin working on the system diagrams for the system described in the case they chose for their project.
8	Students upload the rough draft of their system diagrams.
9	Students add feedback to their classmates’ diagrams using Visio and upload the diagrams to the LMS.
10	Students revise the diagrams using the feedback from classmates and upload the final version to the LMS, then they begin working on the rough draft of the web prototype.
11	Students upload the link to the rough draft of the web prototype.
12	Students review their classmates web prototypes using the feedback form.
13	Students use the feedback to revise their web prototypes and upload the link to the final version to the LMS. Then they record a video presentation of the project.
14	Students upload the video of the project presentation and provide feedback to at least two other classmates on their presentations.

Author Biography

Dr. Mary Lebens is an assistant professor in Management Information Systems in the College of Management at Metropolitan State University in Saint Paul, Minnesota. In addition to researching online learning, she is also currently researching using Agile software development practices in the classroom. Prior to joining higher education, she worked as a software engineer for thirteen years at technology companies, including Oracle. She holds a Master's in Management Information Systems from Metropolitan State University and a Doctorate of Business Administration in Economics and Finance from Saint Mary's University of Minnesota.

.