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INFORMATION SYSTEMS EDUCATION JOURNAL

Editors

Visualizing the Eras of IS Education: A Co-occurrence Analysis of the Information Systems Education Journal

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Abstract

The *Information Systems Education Journal* has published uninterrupted since 2003. Over its publication history, it has covered myriad topics related to information systems education including model curriculum, outcomes assessment, online learning, capstone courses, service learning, data analytics, and cybersecurity, just to name a few. This, first of its kind, study conducts a co-occurrence analysis using article keywords on the corpus of the journal for the years 2003 through 2024. The results are presented in terms of five eras and present frequency counts, clusters, and term maps of the key topics. This paper presents a worthwhile endeavor of examining the past and looking forward to the future. While the future of information systems education is unknown, the *Information Systems Education Journal* provides a consistent outlet to keep information systems educators and researchers abreast of the latest trends and developments.

Keywords: Co-occurrence analysis, cluster analysis, bibliometric review, term map, *ISEDJ*.

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Visualizing the Eras of IS Education: A Co-occurrence Analysis of the Information Systems Education Journal

Jason H. Sharp, John E. Anderson and Guido Lang

1. INTRODUCTION

The study of individual journals or groups of journals is well established and quite common across various disciplines, information systems (IS) notwithstanding (e.g., Krauskopf, 2018; Flis & van Eck, 2018; Liu & Myers, 2011; Merigo, Pedrycz, Weber, & de la Sotta, 2018; Mustafee, 2011; Oskos & Gencer, 2017). Often, one or more techniques under the umbrella of bibliometrics or bibliometric analysis are employed to gain insight into impact, authorship, citations, publications, themes, trends, and patterns (Broadus, 1987; Pritchard, 1969). In that tradition, the purpose of this paper is to conduct a co-occurrence analysis of articles published in the *Information Systems Education Journal (ISEDJ)* from 2003-2024 to identify topics over the course of time as well as look forward to the future of IS education.

ISEDJ published its first volume on September 8, 2003, and has published uninterrupted through its current Volume #22 (2024). As a double-blind peer-reviewed academic journal focused on information systems (IS) education, it covers a wide-array of topics including, but not limited to, model curriculum, outcomes assessment, online and distance education, capstone and service-learning projects, networking, data analytics, and cybersecurity (About, n.d.). *ISEDJ* is listed in Cabells and indexed in ERIC Institute of Education Services. As a publication of the Information Systems and Computing Professionals (ISCAP), the submission process for *ISEDJ* is integrated as a part of the ISCAP Conference and reports a 36% acceptance rate. Per ERIC, 17,800 articles from *ISEDJ* were downloaded in 2022 (Impact, n.d.). Since its inception, five individuals have served as chief editor(s): Donald Colton, Emeritus (2003-2010), Wendy Ceccucci (2011-2012), Nita Brooks (2013-2015), Jeffry Babb, Emeritus (2016-2021), and Paul Witman (2021-present).

2. BACKGROUND

When a journal celebrates a notable anniversary, researchers often conduct a bibliometric-based study to commemorate this important event. This was the case for both the *European Journal of Marketing* and *Information Sciences* when each reached 50 years of publications, respectively (Martinez-Lopez, Merigo, Valenzuela-Fernandez, & Nicolas, 2018; Merigo, Pedrycz, Weber, & de la Sotta, 2018). In each of these studies, various bibliometric techniques were employed including publication counts, bibliographic coupling, citation and co-citation analysis, and co-occurrence analysis of keywords.

Large-scale discipline-specific studies commonly necessitate bibliometric studies as well. For example, Flis and van Eck (2018) conducted a co-occurrence analysis of psychology literature between the years ranging from 1950 to 1999, representing 676,393 articles, while White and McCain (1998), conducted an author co-citation analysis of the information science discipline from the period of 1972 to 1995. Smaller scale studies often examine a specific field, such as Ozkose and Gencer (2017) who analyzed the field of management information systems using bibliographic mapping.

Other well-established approaches include analyzing a single journal such as the case of the *Journal of Infection and Public Health* (Krauskopf, 2019), comparing two journals such as the *European Journal of Information Systems* and *Management Information Systems Quarterly* (Mustafee, 2011), or examining a group or "basket" of journals. For example, the Association for Information Systems (AIS) basket of journals (Bernroider, Pilkington, & Cordoba, 2013; Liu & Myers, 2011). These types of studies are not limited only to journals, as others have analyzed various conference proceedings as well (Olbrich, 2009). Finally, researchers may examine a specific research topic or area such as cybersecurity (Mandani & Ramirez, 2019), ethics and corporate social responsibility (Weiss, 2017), or gender (Zhou & Loiacono, 2023).

3. METHOD

For our study we employed co-occurrence analysis. Co-occurrence networks are defined as the interconnectedness of terms based on their joint presence within a specific text unit. These networks are formed by linking pairs of terms according to criteria that define co-occurrence. For instance, terms A and B are considered to "co-occur" if they both appear in the same article. Or in our case, in the author-supplied keywords. Another article might include terms B and C. By connecting A to B and B to C, a co-occurrence network of these three terms is created. The criteria for defining co-occurrence within a text corpus can be adjusted as needed. For example, a stricter criterion might require that the terms appear in the same sentence or in the author supplied keywords. Co-occurrence networks are particularly useful for analyzing large text datasets and big data, such as identifying main themes and topics in numerous social media posts, uncovering biases in text like news coverage, or mapping the entirety of a field of research (Segev, 2022). We applied co-occurrence analysis to the author-produced keywords of the corpus of *ISEDJ*.

For this paper, we looked at all of the articles published in *ISEDJ* from 2003 to 2024, a total of 1076 articles. We then focused on the author produced key words (the key words submitted with each article) as our primary data, in addition to year. We then chose to group the years into units of five years to make it more digestible, as shown in Table 1.

Grouping Years	Number of Articles
2003-2007	288
2008-2012	332
2013-2017	222
2018-2022	174
2023-2024	60

Table 1: Grouping by Years

We defined the importance of a key word based on simple frequency counts and link strength. A connection between two items is called a link. The strength of a link is represented by a numerical value, such as the number of articles in which two keywords occur together. A visualization of the importance of the key words (called a term map) was then created. A term map shows the relatedness of terms as a function of the distance between them. The more co-occurrences of two terms, the smaller the distance between them. The more articles in which a term occurs, the more prominently the term is displayed in the term map, such as with a larger font size and larger sphere. The terms are also grouped into clusters.

Six term maps were created to get a glimpse into topics academics published in *ISEDJ*. We constructed term maps based on four five-year groupings (2003-2007, 2008-2012, 2013-2017, 2018-2022) and one for the new unfinished group (2023-2024), and one for the entire data. We hoped the groups would yield a picture of the evolution of topics published in *ISEDJ*. The term maps were created using the VOSviewer software (van Eck & Waltman, 2010, 2014). Part of the term map construction was choosing the minimum number of key word term co-occurrence frequency that would be considered "interesting enough" to use. We choose a minimum number of occurrences as three for the evolutionary term maps, and five for the term map of the full data.

Based on the co-occurrence frequency counts VOSviewer constructed term maps where distance between term indicated relatedness, and color was used to cluster the terms into topic areas. VOSviewer uses both a mapping technique (to determine the layout of terms in the term map) and a clustering technique (which assigns frequently co-occurring terms to the same cluster). The mapping technique is called VOS and is related to multidimensional scaling (Borg & Groenen 2005; van Eck, Waltman, Dekker, & van den Berg 2010). The clustering technique used by VOSviewer is related to modularity-based clustering (Newman, 2004; Newman & Girvan, 2004; Waltman et al. 2010).

4. RESULTS

The results of the co-occurrence analysis are presented below for each of the year range groupings including the frequency counts, clusters, and term maps. The colors assigned in the term maps for each era were randomly generated by the VOSviewer software. Unfortunately, we did not have the ability to alter these assigned colors to use the same color for the same topics across eras. We did, however, attempt to match the color in the associated tables for frequency count and clusters.

2003-2007: IS Education

We used the rule that the keyword must occur a minimum of three times to be "interesting" (of 989 keywords, twenty-six met the threshold). Of the twenty-six keywords, 14 (54%) are "education" words such as variants of curriculum, assessment, and pedagogy. See Appendix A, Table 2 for frequency counts. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. Nine clusters were found as shown in Appendix A, Table 3. The term map is provided in Appendix B, Figure 1.

2008-2012: Pedagogy and Student Issues

We used the rule that the keyword must occur a minimum of three times to be "interesting" (of 1117 keywords, 101 met the threshold). The thirty-five keywords with a total link strength of 10 or greater are shown in the table below. Looking at the top thirteen for the 2003-2007 vs 2008-2012 we see a movement from plain vanilla curriculum and assessment issues to broader pedagogy and student issues such as mentoring, retention, scholarships, women, and minorities. See Appendix A, Table 4 for frequency counts. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. Twelve clusters were found as shown in Appendix A, Table 5. The term map is provided in Appendix B, Figure 2.

2013-2017: Cybersecurity-Big Data-Analytic
We used the rule that the keyword must occur a minimum of three times to be "interesting" (of 735 keywords, sixty-five met the threshold). There were thirty-nine keywords with a total link strength of 5 or greater. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. See frequency counts in Appendix A, Table 6. Seven clusters were found as shown in Appendix A, Table 7. The term map is provided in Appendix B, Figure 3.

2018-2022: COVID Impact on IS Education
We used the rule that the keyword must occur a minimum of three times to be "interesting" (of 543 keywords, fifty-six met the threshold). The thirty keywords with a total link strength of 5 or greater are shown in Appendix A, Table 8. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. Eight main clusters were found, in addition to five smaller clusters as shown in Appendix A, Table 9. We combined the smaller clusters with the larger cluster. Some of the fifty-six keywords in the network were not connected to each other. The largest set of connected items consists of thirty-eight items. The fracturing (or less cohesiveness) is interesting. This may be due to the impact of the COVID-19 pandemic. The term map is provided in Appendix B, Figure 4.

2023-2024: Artificial Intelligence
We used the rule that the keyword must occur a minimum of three times to be "interesting" (of 215 keywords, eighteen met the threshold). All eighteen keywords are shown in Appendix A, Table 10. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. Three clusters were found as provided in Appendix A, Table 11. The term map is presented in Appendix B, Figure 5.

2003-2024: Full Network
We used the rule that the keyword must occur a minimum of five times to be "interesting" (of 2827 keywords, 115 met the threshold). The fifty keywords with a total link strength of 16 or higher are shown in Appendix A, Table 12. The clusters are made up of the terms that are closest to each other, yet also farther away from other terms. Nine clusters were found as shown in Appendix A, Table 13. The term map is presented in Appendix B, Figure 6. Appendix B, Figure 7 shows the time overlay for the full network.

5. DISCUSSION

For the purpose of discussion each grouping of years is defined as an era. An examination of the topics and factors affecting the choice of topics during each era is then presented.

Era 1: 2003-2007
The first era of *ISEDJ* is characterized by topics associated with IS education. Topics such as curriculum, assessment, and information systems, accreditation, ethics, and pedagogy round out the top three occurrences of keywords. As mentioned previously, these topics represent "education" words. Ethics may be considered a bit of an outlier, however; it is hoped that ethics underlies all aspects of IS education. Also interesting was the separation of curriculum assessment and accreditation as seen in the term map. As a young discipline in this era there was greater interest in solidifying the curriculum, with accreditation just starting to be an important issue. It might be noted that in these early years of the journal, all articles were included in a single volume, without the use of individual issue numbers. Perhaps this was due to a more heterogenous set of topics and less diversity of topics at the time.

Era 2: 2008-2012
The evolution from Era 1 to Era 2 experienced several changes. First, security curriculum development dropped out of the topics. Perhaps, this area matured to the point that educators felt they had gained a good grasp of security curricula. Not surprisingly, retention, social networking, and outsourcing appeared in this era. With the 2008 financial crisis, it is quite possible that the current emphasis on retention began. It is common sense that when students have financial difficulties they often must drop out of school to take care of their responsibilities. The 2010s saw the growth of numerous social

networking platforms including Facebook, LinkedIn, Snapchat, and Twitter. Consequently, the use of these platforms in higher education and in IS education research saw subsequent growth. Interestingly, from Era 1 to Era 2, ethics grew into own cluster. Traditional topics such as programming, assessment, accreditation, and IS curriculum continued into this era. In the term map we see the merging of assessment and accreditation with the emergence of terms such as learning outcomes and program assessment. Perhaps this era shows the focus shift from curriculum assessment to program assessment and accreditation. Also in this era, Volume 11 - 2009, was the beginning of creating separate issue numbers rather than publishing all articles in a single volume.

Era 3: 2013-2017
The evolution from Era 2 to Era 3 saw the loss of social networking, retention, outsourcing, and ethics. Perhaps the ubiquitous nature of social networking led to its absence in this area. It had simply become a normal part of life and education. The tumultuous times created by the 2008 financial crisis were subsiding and students were returning to continue their education lessening the overall emphasis on retention. After two eras, ethics fell out of the topics. It is hard to say ethic was no longer important, but again, perhaps it had become ingrained in the context of IS education. Era 3 saw the reemergence of cybersecurity into its own cluster. The continued growth of the Internet and the Web and numerous data leaks and security breaches throughout the era contributed to the growth and popularity of cybersecurity. Pedagogy and big data/analytics also saw the formation of their own clusters. Along with cybersecurity, this era saw the growth and popularity of big data/analytics. In fact, a common movement at the time was for IS programs to rebrand as Business Analytic programs. As in previous eras, programming, assessment, IS curriculum, and online learning continued to be common topics. Interestingly when looking at the term map we see a refocus of assessment from program assessment back to curriculum assessment, especially the assessment of experiential learning.

Era 4: 2018-2022
The evolution from Era 3 to Era 4 experienced a notable shift. The long-standing topics of programming and assessment were absent. While a direct connection may not be possible, it is interesting to note that a significant change in the *IS 2010 Curriculum Guidelines for Undergraduate Degree Programs in Information Systems* (Topi et al., 2010) was the removal of application development (IS 2002.5 Programming, Data, File, and Object Structures) from the previous curriculum guidelines. A clear explanation for the loss of assessment is a bit more difficult to identify. New developments include the splitting of analytics into two clusters: business analytics and data analytics. This split certainly reflects the growth and popularity of this area. It also saw the movement of business analytics as primarily housed within the College of Business and data analytics housed in various places such as Business, Mathematics, Statistics, and Engineering. This era also saw the appearance of topics related to the COVID-19 pandemic. In particular the growth of topics related to attendance and attentiveness might have been a direct result. While the capstone course was a regular topic in previous eras, it became its own cluster in Era 4. Cybersecurity, pedagogy, online learning, and IS curriculum remained consistent in this era. Assessment fell out of importance except as a part of cybersecurity, which makes sense as the need to assess and solidify the new cybersecurity curriculum was important.

Era 5: 2023-2024
The evolution from Era 4 to Era 5 saw the loss of several long-standing topics including cybersecurity, online learning, assessment, attendance, attentiveness, IS Curriculum, and capstone course. The number of clusters moved from 8 to 3 (Pedagogy, Analytics, and AI). This may be due simply to natural attrition. That is, these topics are so much a normal part of IS education that the novelty has worn off a bit and so they fall out of favor as research topics. It should be noted, in regard to cybersecurity in particular, that ISCAP introduced the *Cybersecurity Pedagogy and Practice Journal (CPPJ)* in 2022 as a publication outlet associated with the ISCAP Conferences. This may account for the absence of cybersecurity-related topics in *ISEDJ*. With the release of ChatGPT in 2022 and numerous other Generative Artificial Intelligence platforms to follow since, it is not a surprise that artificial intelligence appeared. Analytics and pedagogy continued their inclusion.
It should be noted that Era 5 only presents two years.

Looking at the movement or ranking changes of themes through the eras we see that Assessment/Accreditation went from 1 to 5 to 3 to 5 to null (went from first to middle ranking). Pedagogy went from 4 to 1, to 1 to 1 to 2 (highest overall ranking). Programming went from 5 to 9 to 6 to partial 3 to null (lower-middle ranking).

Cybersecurity really started in Era 3 and was ranked 4 then 5 then null (middle ranking). Analytics really started in Era 2 and was ranked 7 then 5 and 7 then 6 then 1 (moved from middle to first). Student Issues came to the foreground in Eras 2 and 4 ranked 3 and 4 (Era 2 blossoming concern for students, COVID-19 era concern for students). See Appendix A, Table 14 for the rank changes from Eras 1 to 5.

From the viewpoint of the number of clusters each term map shows for each era we see that era 1 had 9 clusters, era 2 had 12, era 3 had 7, era 4 had 8, and finally era 5 had just 3. It would appear that era 2 from 2008-2012 was the richest and most diverse era of IS education scholarship. Also, although era 5 is only half-way completed, it would appear that the diversity of IS education has shrunk.

Lastly, the Full Network Term Map (Figure 6) shows the wonderful growth and diversity of IS Education scholarship produced in that past 22 years. We are struck by the continuous central focus of work produced in the areas of pedagogy and curriculum, which are at the heart of student success. It is in a way a painting of the IS Educator landscape, a landscape probably vastly different from that of the IS Researcher producing work in the Basket of Eight.

6. CONCLUSION

This is the first known study to examine the full corpus of *ISEDJ* available at the time it was conducted. To see how IS education has changed as well as has stayed the same over the years is quite interesting and serves to honor the past as well as inform the future.

Limitations

The study is not without its limitations. The most obvious is that the co-occurrence analysis relies solely on author-supplied keywords. Inherent in this methodology is a potential bias toward the terms and buzzwords of any given era. Another potential limitation is the publishing of special issues of *ISEDJ* such as teaching cases which may serve to artificially inflate the occurrence of a term(s) in a particular era. Because of the potential limitation resulting from the sole use of author-supplied keywords, future research might include the addition of title and abstract to the co-occurrence analysis to increase the likelihood of otherwise unforeseen or obvious topics.

Future Directions

For over two decades *ISEDJ* has kept up with the dynamic nature of IS education as shown by the evolutionary nature of the topics contained in each era of its 1,076 articles published between 2003-2024. In this particular study, the authors chose to establish predefined five-year groupings for analysis and determination of "eras". In future research, the authors plan to implement a more organic approach, by allowing the data itself to establish "eras" of topicality. Furthermore, with the continued growth and popularity of artificial intelligence, in general, and generative artificial intelligence, specifically, continued co-occurrence analysis of ISEDJ may reveal a preponderance of research in this area in the future.

7. REFERENCES

About. (n.d.). Information Systems Education Journal. https://isedj.org/about.html

Bernroider, E. W. N., Pilkington, A., & Cordoba, J. (2013). Research in information systems: A study of diversity and inter-disciplinary discourse in the AIS basket journals between 1995 and 2011. *Journal of Information Technology*, 28, 74-89. https://doi.org/10.1057/jit.2013.5

Borg, I., & Groenen, P. J. F. (2005). *Modern multidimensional scaling: Theory and applications* (2nd ed.) Springer Science + Business Media. https://doi.org/10.1007/0-387-28981-X

Broadus, R. N. (1987). Toward a definition of "bibliometrics". *Scientometrics*, 12, 373-379. https://doi.org/10.1007/BF02016680

Flis, I., & van Eck, N. J. (2018). Framing Psychology as a discipline (1950-1999): A large-scale term co-occurrence analysis of scientific literature in Psychology. *History of Psychology*, 21(4), 334-362. https://doi.org/10.1037/hop0000067

Impact. (n.d.). Information Systems Education Journal. https://isedj.org/impact.html

Krauskopf, E. (2018). A bibliometric analysis of the Journal of Infection and Public Health. *Journal of Infection and Public Health*, 11, 224-229. https://doi.org/10.1016/j.jiph.2017.12.011

Liu, F., & Myers, M. D. (2011). An analysis of the AIS basket of top journals. *Journal of Systems and Information Technology*, 13(1), 5-24. https://doi.org/10.1108/13287261111118322

Mandani, A., & Ramirez, R. (2019).

Cybersecurity: Current state of governance literature. *Proceedings of the Twenty-fifth Americas Conference on Information Systems*, 16, 1-5.

Martinez-Lopez, F. J., Merigo, J. M., Valenzuela-Fernandez, L., & Nicolas, C. (2018). Fifty years of the European Journal of Marketing: A bibliometric analysis. *European Journal of Marketing*, 52(1/2), 439-468. https://doi.org/10.1108/EJM-11-2017-0853

Merigo, J. M., Pedrycz, W., Weber, R., & de la Sotta, C. (2018). Fifty years of Information Sciences: A bibliometric overview. *Information Sciences*, 432, 245-268. https://doi.org/10.1016/j.ins.2017.11.054

Mustafee, N. (2011). Evolution of IS research based on literature published in two leading IS journals – EJIS and MISQ. *Proceedings of the Nineteenth European Conference on Information Systems*, 228.

Newman, M. E. J. (2004). Fast algorithm for detecting community structure in networks. *Physical Review E*, 69(6). https://doi.org/10.1103/PhysRevE.69.066133

Newman, M. E. J., & Girvan, M. (2004). Finding and evaluating community structure in networks. *Physical Review E*, 69(2). https://doi.org/10.1103/PhysRevE.69.026113

Olbrich, S. (2009). Reflecting the past decades of ICIS, ECIS, and AMCIS proceedings – a Design Science perspective. *Proceedings of the Thirtieth International Conference On Information Systems*, 116, 1-8.

Özköse, H., & Gencer, C. (2017). Bibliometric analysis and mapping of Management Information Systems field. *Gazi University Journal of Science*, 30(4), 356-371.

Pritchard, A. (1969). Statistical bibliography or bibliometrics. *Journal of Documentation*, 25(4), 348-349.

Segev, E. (Ed.). (2021). Semantic Network Analysis in Social Sciences. Routledge.

Topi, H., Valacich, J. S., Wright, R. T., Kaiser, K. M., Nunamaker, Jr., J. F., Sipior, J. C., & de Vreede, G. J. (2010). IS 2010: Curriculum guidelines for undergraduate degree programs in Information Systems. *Communications of the Association for Information Systems*, 26(18), 359-428. https://doi.org/10.17705/1CAIS.02618

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, 84(2), 523-538. https://doi.org/10.1007/s11192-009-0146-3

van Eck, N. J., & Waltman, L. (2014). Visualizing bibliometric networks. In Y. Ding, R. Rousseau, & D. Wolfram (Eds.), *Measuring scholarly impact: Methods and practice* (pp. 285-320). Springer. https://doi.org/10.1007/978-3-319-10377-8_13

van Eck, N. J., Waltman, L., Dekker, R., & van den Berg, J. (2010). A comparison of two techniques for bibliometric mapping: Multidimensional scaling and VOS. *Journal of the American Society for Information Science and Technology*, 61(12), 2405-2416. https://doi.org/10.1002/asi.21421

Waltman, L., van Eck, N. J., & Noyons, E. C. M. (2010). A unified approach to mapping and clustering of bibliometric networks. *Journal of Informetrics*, 4(4), 629-635. https://doi.org/10.1016/j.joi.2010.07.002

Weiss, J. W. (2017). Ethics and CSR research in top ranked IS journals, 1980-2013: A developing trend or anomaly? *Proceedings of the Fiftieth Hawaii International Conference on System Sciences*, 5758-5762.

White, H. D., & McCain, K. W. (1998). Visualizing a discipline: An author co-citation analysis of Information Science, 1972-1955. *Journal of the American Society for Information Science*, 49(4), 327-355. https://doi.org/10.1002/(SICI)1097-4571(19980401)49:43.0.CO;2-4

Zhou, S., & Loiacono, E. (2023). A review of gender research in Information Systems: From bibliometric analysis to future research directions. *Proceedings of the Twenty-fifth Southern Association for Information Systems Conference*, 56.

APPENDIX A
Frequency Count and Cluster Tables

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
curriculum	21	19	electronic commerce	6	4
assessment	15	15	is curriculum	8	4
information systems	12	14	model curriculum	5	4
accreditation	5	11	curriculum development	8	3
ethics	10	10	distance education	6	3
pedagogy	9	9	service learning	7	3
database	8	8	computer information systems	5	2
education	8	8	distance learning	11	2
information technology	8	8	e-commerce	6	2
computer literacy	5	5	project management	8	2
is education	8	5	technology	5	2
systems analysis and design	7	5	information systems curriculum	5	1
course design	5	4	programming	6	1

Table 2: 2003-2007 Frequency Counts

Curricula	Programming	Assessment	e-learning/ e-commerce	IS Core	Systems Analysis & Design	IST Computer Literacy	Security Curriculum Development	Accreditation
case study	.net	assessment	collaborative learning	curriculum design	capstone course	capstone	curriculum development	accreditation
cis	abet	certification	distance learning	gis	course design	computer literacy	information security	
computer information systems	application development	computer	e-business	is curriculum	methodology	higher education	is model curriculum	
distance education	cobol	curriculum	e-commerce	is education	project management	information systems	pedagogy	
information systems curriculum	database	education	electronic commerce	open source software	service learning	information technology		
information systems education	grading	innovation	ethics	sdlc	significant learning	usability		
is 2002 model curriculum	is accreditation	model curriculum	internet	software engineering	systems analysis and design			
is curricula	java	security	privacy	systems analysis				
it curriculum	programming	technology	small college	web design				
it education	software tools	testing						
mis	systems development							
online education								
outsourcing								

Table 3: 2003-2007 Clusters

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
pedagogy	25	43	abet	8	14
information systems	15	33	accreditation	9	14
information systems education	15	24	management information systems	8	14
mentoring	5	22	assessment	10	13
retention	6	22	is curriculum	12	13
scholarships	4	21	is education	8	13
women	5	21	learning	9	13
computer science	6	20	database	7	12
education	11	20	distance education	10	12
web 2.0	10	20	enterprise systems	6	12
minorities	4	19	ethics	12	12
computer literacy	12	18	outsourcing	7	12
graduates	3	18	social networking	4	11
curriculum	17	17	business intelligence	6	10
higher education	7	17	curriculum design	7	10
information technology	9	17	information systems curriculum	5	10
software engineering	5	16	systems analysis and design	7	10
mathematics	4	15			

Table 4: 2008-2012 Frequency Counts

Computer-mediated learning	IS Curriculum	Data (base) (analytics)	Retention	Social Networking	Systems Analysis & Design	IST Education	Assess/Accred	Programming	Outsourcing	Pedagogy	Ethics
blackboard	capstone experience	business intelligence	framework	collaborative learning	active learning	case studies	abet	alice prog lang	is 2002	is research toward educators	copyright
capstone	curriculum design	computer literacy	gestalt	is pedagogy	capstone course	distance learning	accreditation	intro prog	it workers	is undergrad curriculum	ethics
cloud computing	curriculum dev	data mining	graduates	instant messaging	cis	is education	assessment	java	offshoring	pedagogy	
computer science	design	data modeling	mathematics	internet	curriculum	information technology	assurance of learning	programming	outsourcing		
computers	erp	database	mentoring	mobile computing	is 2002	motivation	information literacy	prog lang	skills		
distance ed	enterprise systems	database design	minorities	outcomes assessment	project management	online education	learning outcomes	security			
education	faculty	feedback	retention	privacy	service learning	soft skills		security educ			
elearning	higher ed	knowledge management	scholarships	social networking	systems analysis & design						
entrepreneurship	information systems	laboratory-based learning	tutoring	twitter							
is curr	is curriculum	mis	women								
learning	model curriculum	normalization									
learning management system	sap										
online learning	software engineering										
service-oriented architecture											
technology											
web 2.0											
web services											

Table 5: 2008-2012 Clusters

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
active learning	14	26	assessment	7	7
is curriculum	11	18	curriculum	7	7
pedagogy	11	15	e-learning	3	7
online learning	9	14	engagement	4	7
experiential learning	8	13	java	4	7
information systems education	6	13	problem solving	3	7
cyberbullying	4	12	security	4	7
privacy	6	12	social media	7	7
programming	9	12	business analytics	5	6
social networking	5	12	business intelligence	5	
analytics	6	11	information technology	4	6
big data	8	11	learning styles	3	6
flipped classroom	6	11	online education	3	6
cybersecurity	6	10	abet	3	5
it strategy	5	10	accreditation	3	5
inverted classroom	3	9	course design	3	5
systems analysis and design	7	9	data science	3	5
cyberharassment	3	8	teaching	3	5
distance education	4	8	team-based learning	3	5
higher education	4	8			

Table 6: 2013-2017 Frequency Counts

Cybersecurity	Programming	Online Learning	Big Data	Pedagogy	IS Curriculum??	Assessment
classroom innovation	collaborative learning	course design	big data	active learning	analytics	abet
curriculum development	curriculum	distance education	business analytics	cloud computing	database design	accreditation
cyberbullying	it strategy	e-learning	business intelligence	flipped classroom	engagement	assessment
cyberharassment	java	erp	community engagement	information systems education	entrepreneurship	database
cybersecurity	music	learning styles	data science	inverted classroom	information systems	experiential learning
education	programming	online classes	information systems curriculum	is curriculum	problem solving	is education
higher education	project management	online education	is2002 model curriculum	pedagogy	social media	
information technology	python	online learning	privacy	student engagement	systems analysis and design	
instructional design	team-based learning	teaching	teaching case			
security						
social networking						

Table 7: 2013-2017 Clusters

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
pedagogy	22	32	scrum project	3	12
online learning	7	26	student performance	3	12
pandemic	6	26	learned helplessness	5	10
covid 19	5	25	procrastination	6	10
faculty	5	25	data analytics	12	10
grading impact	5	25	apprenticeship	3	9
remote learning	5	25	assessment	4	6
capstone course	4	13	education	4	6
scrum	4	13	information systems	6	6
asp.net mvc	3	12	work-based learning	3	6
attendance	3	12	business analytics	7	5
attentiveness	3	12	certification	3	5
cybersecurity	12	12	coding bootcamps	3	5
distraction	3	12	content analysis	3	5
participation	3	12	data science	3	5

Table 8: 2018-2022 Frequency Counts

Cybersecurity	Pedagogy	Business Analytics	Online Learning	Data Analytics	Attendance-Attentiveness	IS Curriculum	Capstone Course
apprenticeship	active learning	business analytics	covid 19	data analytics	attendance	competency	agile
assessment	certification	coding bootcamps	faculty	data science	attentiveness	curriculum	asp.net mvc
cybersecurity	computing education	content analysis	grading impact	education	distraction	information systems	capstone course
digital badge	covid-19	education in data analytics	online learning	retention	participation	information systems curriculum	scrum
digital literacy	pedagogy	is curriculum	pandemic	stem	student performance	project management	scrum project
learning outcomes	raspberry pi	programming	remote learning	teaching strategies		higher education	
online education	systems analysis and design	student satisfaction			learning		
work-based learning					self-regulated learning		
	learned helplessness				disabilities		
	procrastination						

Table 9: 2018-2022 Clusters

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
experiential learning	7	21	data literacy	3	8
data analytics	7	19	tableau	3	8
pedagogy	8	18	artificial intelligence	6	6
curriculum development	4	16	information systems	4	5
interdisciplinary	3	15	business education	3	3
practicum	3	15	curriculum	3	3
analytics	4	11	chatgpt	3	2

data visualization	6	9	cybersecurity	4	2
excel	3	9	machine learning	4	2

Table 10: 2023-2024 Frequency Counts

Analytics/Data Viz	Pedagogy	AI
analytics	curriculum development	artificial intelligence
business education	data analytics	chatgpt
curriculum	experiential learning	cybersecurity
data literacy	interdisciplinary	information systems
data visualization	pedagogy	machine learning
excel	practicum	
tableau		

Table 11: 2023-2024 Clusters

Keyword	Occurrences	Total link strength	Keyword	Occurrences	Total link strength
pedagogy	75	106	business intelligence	14	24
curriculum	51	63	is education	21	23
information systems	45	62	distance education	20	22
online learning	26	51	abet	14	21
assessment	37	44	computer literacy	18	21
information systems education	25	44	online education	15	21
information technology	23	42	security	15	21
is curriculum	37	42	social networking	9	20
education	27	39	information systems curriculum	17	19
faculty	10	39	retention	11	19
accreditation	19	37	service learning	15	19
active learning	26	37	student perceptions	9	19
data analytics	20	35	analytics	11	18
pandemic	8	32	curriculum design	14	18
privacy	16	32	cybersecurity	22	18
ethics	25	31	internet	8	18
experiential learning	19	31	learning	15	18
covid 19	6	30	software engineering	12	18
grading impact	6	30	web 2.0	13	18
remote learning	6	30	business analytics	14	17
systems analysis and design	24	29	capstone course	14	17
computer science	11	28	cyberbullying	6	17
higher education	19	26	entrepreneurship	11	17
curriculum development	19	25	big data	10	16
database	19	25	certification	10	16
programming	24	25	distance learning	17	16

Table 12: Full Network Keyword Frequency and Total Link Strength (sorted by Total Link Strength)

Ethics/Privacy Social Net	Curriculum Assessment	Analytics	Pedagogy	Distance Ed Learning	MIS Ed Issues	IS Topics	COVID impact on Online Learning	Programming
capstone	abet	analytics	active learning	computer literacy	computer science	enterprise systems	covid 19	intro programming
cloud computing	accreditation	artificial intelligence	agile	course design	design	higher education	faculty	java
collaborative learning	assessment	big data	capstone course	distance education	education	information systems	grading impact	programming
cyberbullying	case study	business analytics	covid-19	distance learning	enrollment	information systems curriculum	online learning	programming language
e-commerce	certification	business intelligence	curriculum development	e-learning	is curricula	information technology	pandemic	python
electronic commerce	computer information systems	critical thinking	experiential learning	erp	management information systems	instructional design	remote learning	
entrepreneurship	curriculum	curriculum design	is curriculum	flipped classroom	mentoring	learning outcomes	erp	
ethics	database	cybersecurity	is education	framework	outsourcing	simulation	information systems curriculum	
information systems curriculum	database design	data analytics	it strategy	information systems education	retention	software engineering		
innovation	is 2002 model curriculum	data mining	motivation	learning	scholarships			
internet	is model curriculum	data science	online teaching	learning styles	skills			
mobile computing	it curriculum	data visualization	pedagogy	online education	women			
privacy	it education	information security	procrastination	teaching				
social networking	normalization	machine learning	project management					
technology	project based learning	social media	service learning					
web 2.0	security	student perceptions	student engagement					
web development	soft skills							
web services	systems analysis and design							

Table 13: Full Network Clusters

Rank	Era 1	Era 2	Era 3	Era 4	Era 5
1	curriculum, assessment, accreditation, model curriculum	pedagogy	pedagogy	pedagogy, Covid 19	analytics, data viz
2	ist computer literacy	IS curriculum	online learning	online learning, pandemic, faculty, grading impact, remote learning	pedagogy
3	ethics, e-learning, e-commerce	Student Issues: mentoring, retention, scholarships, women, minorities	assessment, experiential learning	capstone course, scrum, asp.net mvc, scrum project	AI
4	pedagogy, curriculum development	online education	cybersecurity, cyberbullying, social networking	attendance, attentiveness, distraction, participation, student performance	
5	programming, database	accreditation, assessment	analytics, privacy	cybersecurity, apprenticeship, assessment	
6	IS core	IS education	programming	data analytics, education, data science	
7	SAD, course design, service learning, project management	Database, data analytics	analytics, engagement, problem solving, social media	business analytics, coding bootcamps, content analysis	
8	Curriculum variations	Ethics			
9		Programming			

Table 14: Rank Changes from Eras 1 to 5

APPENDIX B
Term Maps

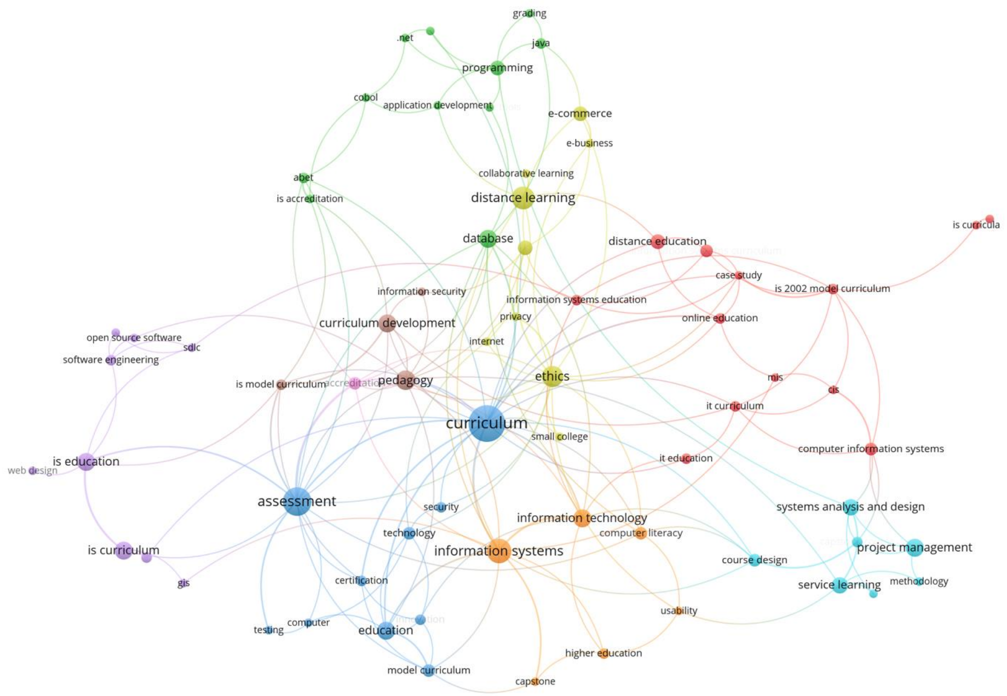

Figure 1: 2003-2007 Term Map

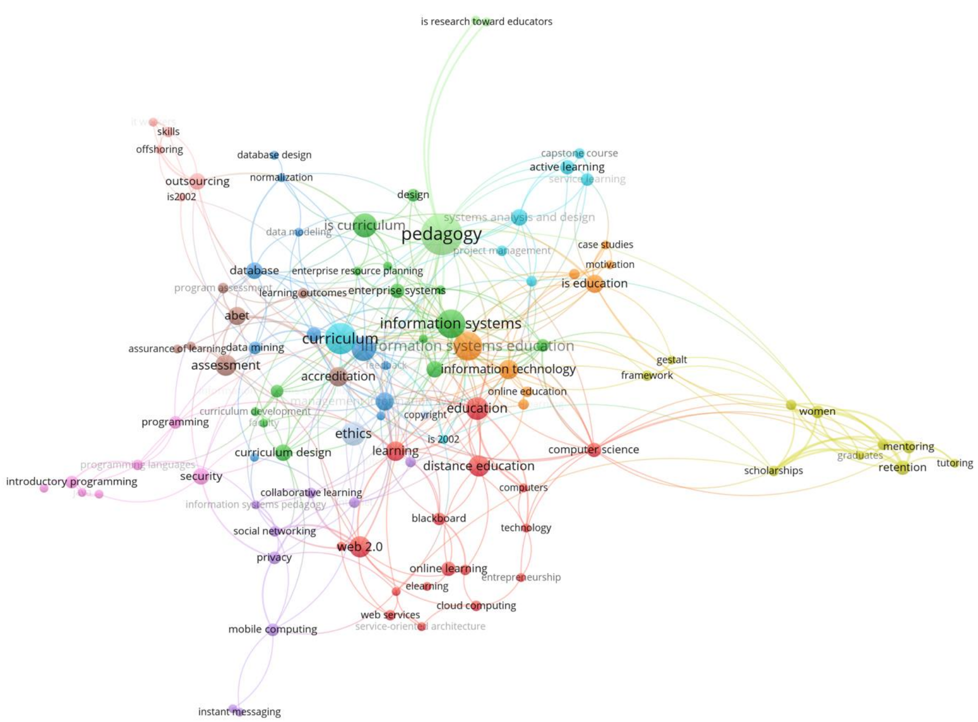

Figure 2: 2008-2012 Term Map

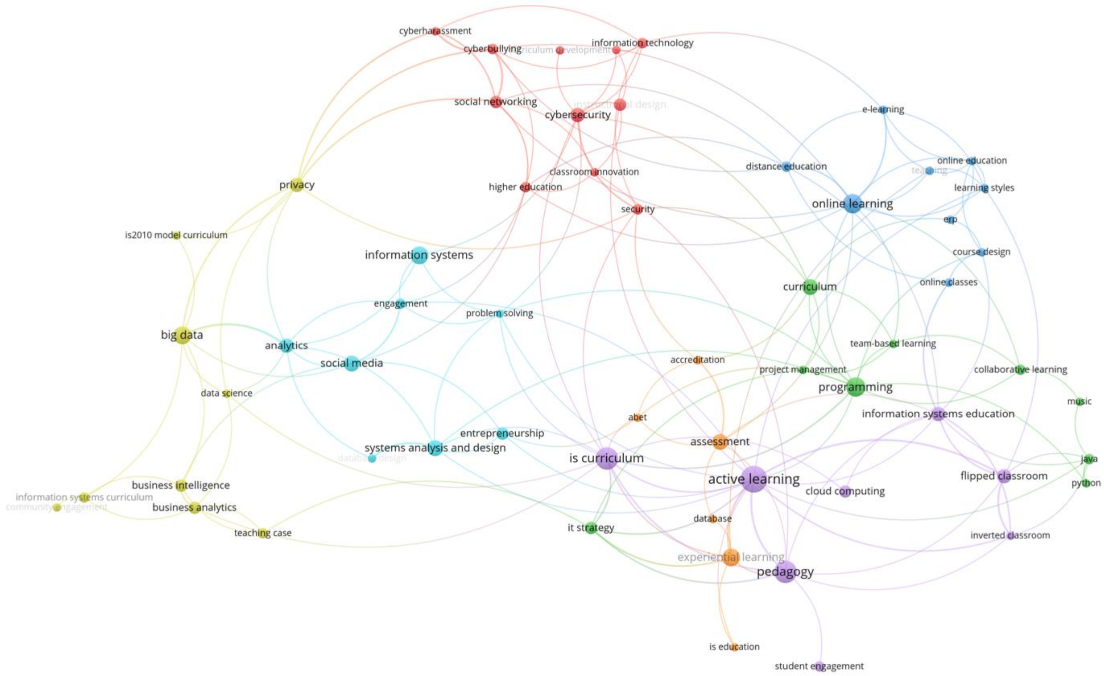

Figure 3: 2013-2017 Term Map

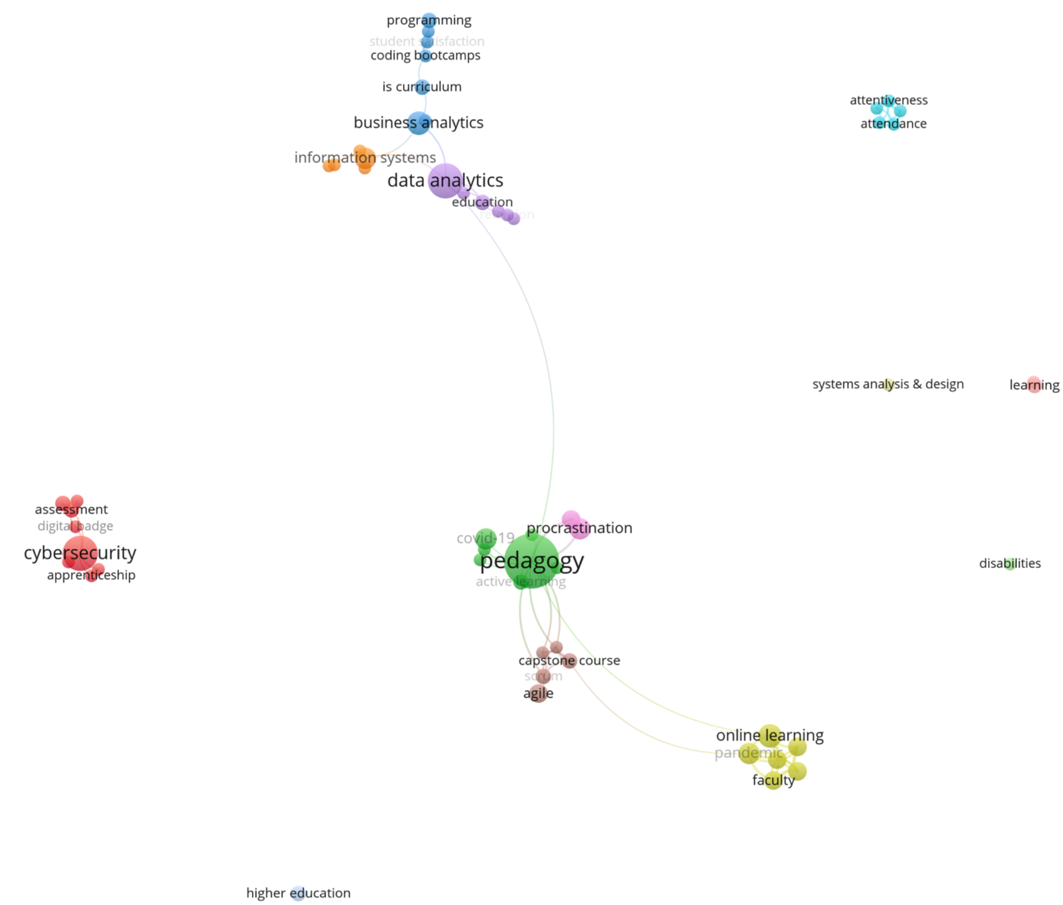

Figure 4: 2018-2022 Term Map

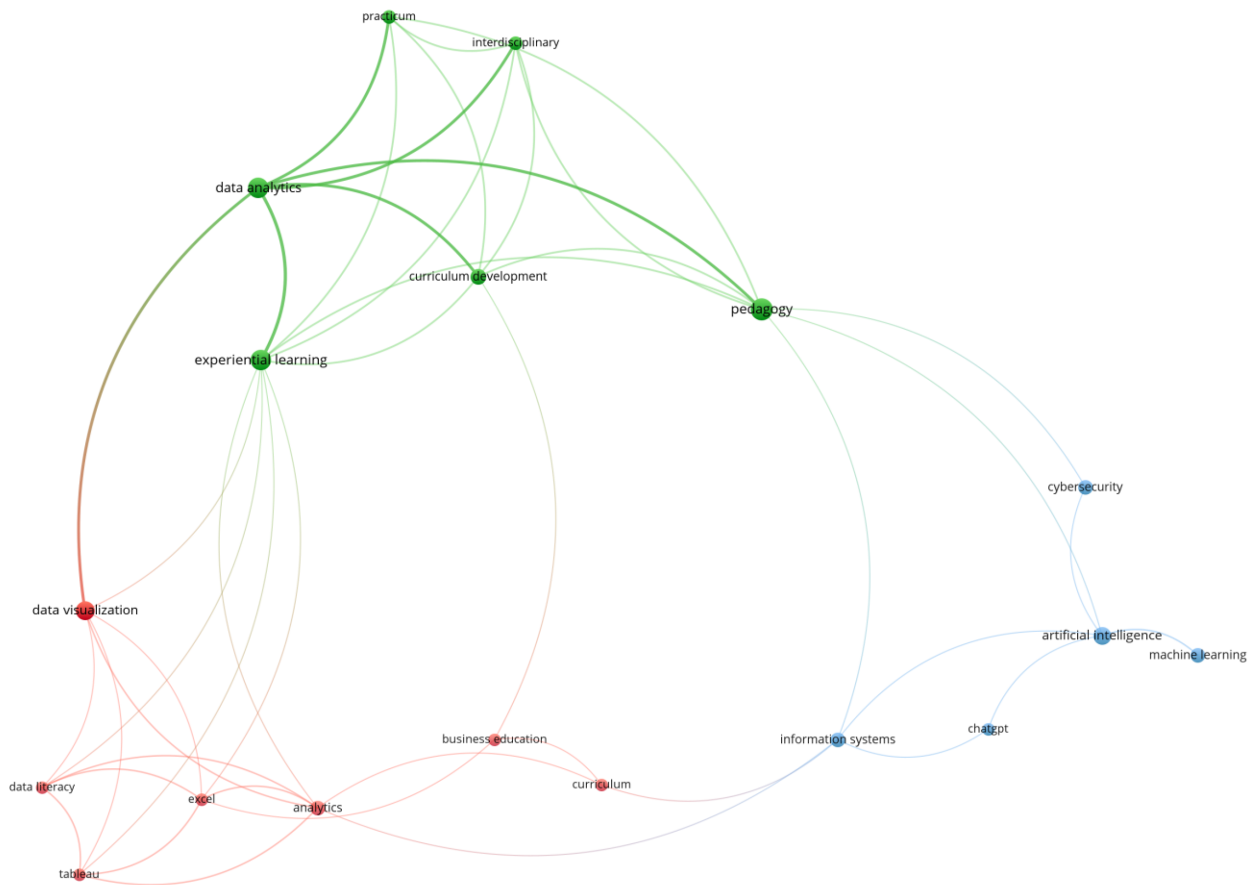

Figure 5: 2023-2024 Term Map

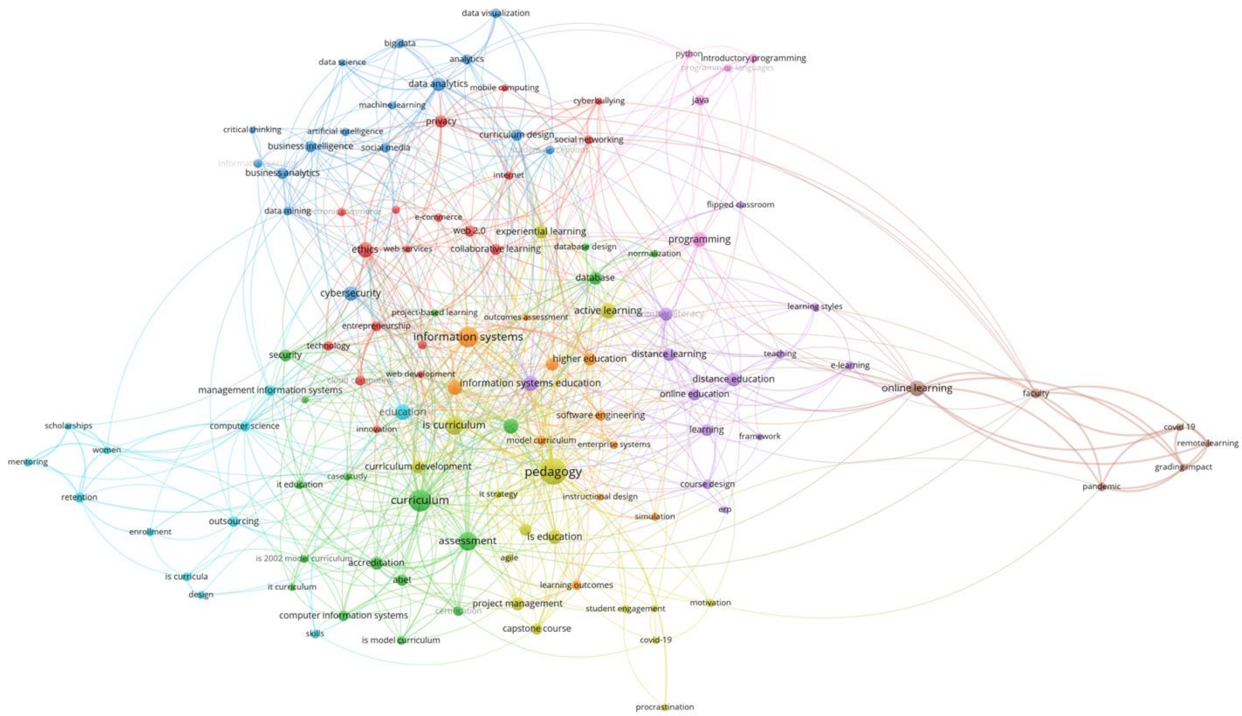

Figure 6: Full Network Term Map

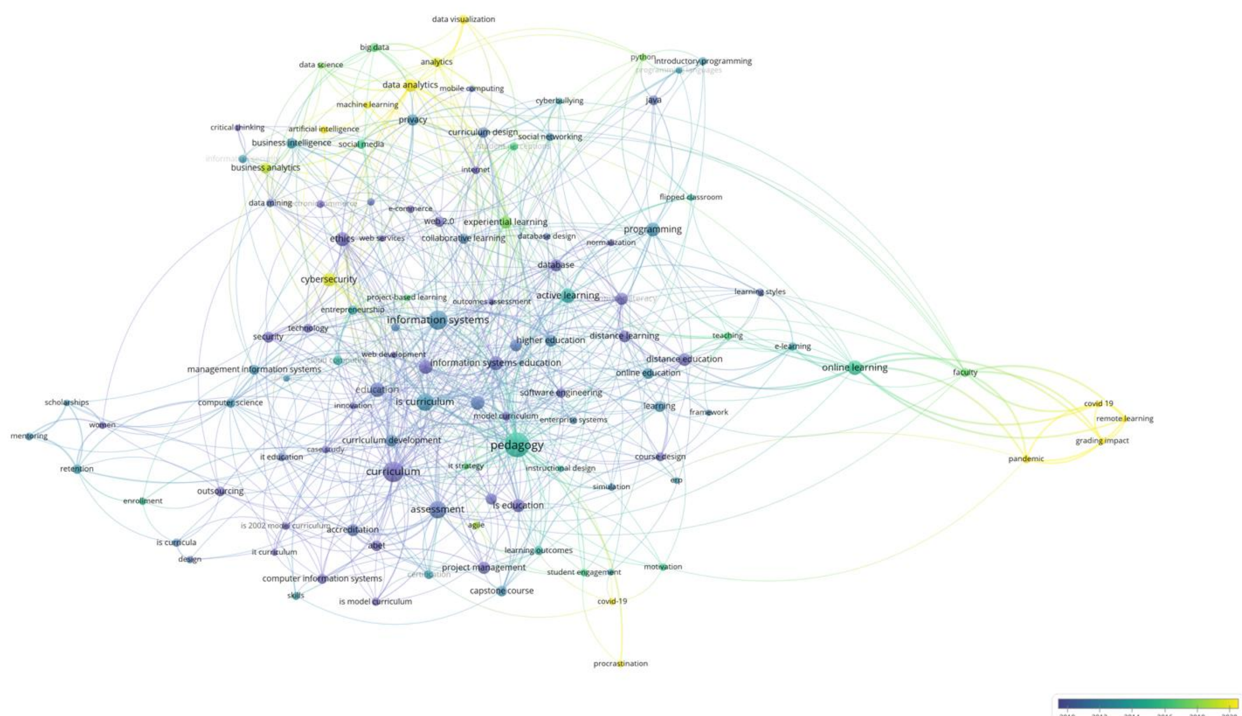

Figure 7: Full Network Time Overlay

Online Maps and Route-Finding – Huge Success, With Some Nagging Problems …

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Leverage students' real-world experiences in the use of online maps and routes to discuss fundamental IT and business principles including maps, routing, multi-factor decisions, as well as gathering, evaluating, and using information.

Abstract

Technological tools continue to permeate modern life, to the extent that they can supplant previously fundamental skills. Maps and route-finding are no exception. This complex function, driven by huge volumes of data, makes modern transportation easier, more resilient, and at the same time riskier and more dependent on a sometimes-opaque technology and revenue model. This case study explores a variety of instances of online mapping and route-finding, and invites the student to consider how these routes are identified and influenced.

Keywords: Teaching Case, Online Maps, Route-finding, Route optimization, Rerouting.

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Online Maps and Route-Finding – Huge Success, With Some Nagging Problems …

Paul D. Witman, Jim Prior, Tracy Nicki, Christopher Njunge, Stephen Ng'etich and Ayla Chaudhry

1. OPENING STORY

Helen was on a seemingly straightforward, 5-hour drive northeast from Los Angeles to Las Vegas to pick up her son at the airport, en route to Utah for Thanksgiving. But what started as a time-saving detour ended for her in a 2-hour delay, only to get back to where she started the detour.

Early morning on Monday before Thanksgiving 2023, Google Maps had said the route was in good shape – north on Interstate 15 (I15) from Victorville to Las Vegas. All was well until she approached the Nevada border. At about 2 p.m., authorities had issued a closure notice for that section of the freeway due to dust storms.

She did not know about the closure at the time. She had only relied on the visual map updates to re-route around issues. Google Maps said she should get off at an isolated desert gas station exit and take an excursion several miles to the north of I15 (see Figure 1), for about 40 miles total. This would (per Google Maps) save her 56 minutes of travel time.

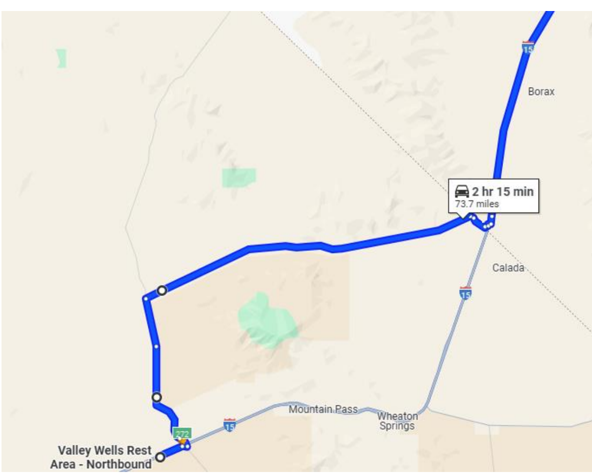

Figure 1: Google Maps and its Nov 2023 proposed diversion around a dust storm (Source: Google Maps)

More details will follow in Scenario 1, below – but in short, the detour was impassable. She spent two hours on that diversion – 5 minutes going away from the highway, and the rest of the time moving very slowly to get back to the highway once she was alerted to the impassable route. News reports the next day confirmed that Google had indeed been recommending an impassable detour.

Google Maps later issued an apology for this issue and indicated that they would "no longer recommend" (DuBose, 2023) this detour.

We hope that this set of real-world cases will help students understand and analyze these situations from several fundamental perspectives. Note that all references to people by first name only are real people unless stated otherwise.

2. TECHNICAL BACKGROUND

There are a number of technical concepts that apply to various aspects of this case, and we identify and describe them briefly here.

Theoretical Underpinnings of Online Maps and Routing

The fundamental principle behind route-finding treats a map as a series of road segments, of varying length. The map services capture static data about those segments (endpoints, length, shape, speed limit, slope, etc.). They also capture and can respond to dynamic (live) data, including actual speeds, reported issues, and details about actual driver behavior in those areas. Each segment (known in graph mathematics as an edge) is connected to its neighbor segments by a node, which could be a road continuation or an intersection of some sort, with or without traffic controls.

Choosing a route is a function of many parameters. One of these functions examines the desired start and end points of the requested route, and then lays out alternative graph paths that will accomplish the desired end points. Multiple routes are tested to find the best one, based on a range of criteria (Gregory, 2011). While this is not a treatise on the complexity of the problem, we outline the challenges to help better understand the root causes of mapping and routing issues.

The fundamental algorithm for doing that step is called A* (Luxen & Vetter, 2011), and its primary function is to find the best path between two points on a graph. There is metadata about each edge (the connection between nodes) that describe that edge's speed limit, energy cost, tolls, traffic, etc. The combination of this metadata aggregated across each potential route is used to find the best route(s).

As a visual example, consider the 4x4 graph below, with its 16 segments or edges and its 16 nodes. Getting from A to P could be done hundreds of ways, many of which would be illogical to a human traveler. We have outlined three of them below, in Figure 2.

- Fewest turns
- Zig-zagging diagonally across
- A more circuitous route that involves some apparent backtracking

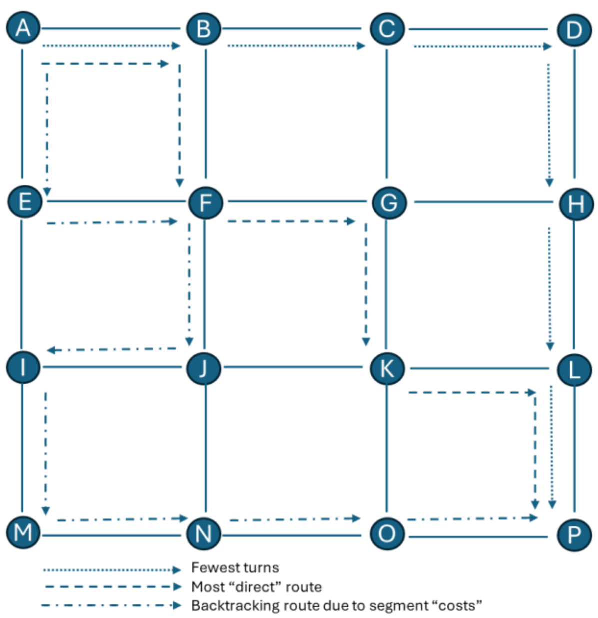

Figure 2: Example graph traversals (adapted from (Gregory, 2011))

That said, it is not obvious from the information in Figure 2 which route is evaluated as best. We do not know speed or cost in any units, and we do not know what any specific user would call best. These route options also may result in apparent irrational routes, such as the one with backtracking in Figure 2.

The algorithm can also quickly become computationally expensive, comparing vast numbers of potential routes even for short distances. The map-routing variants of this algorithm narrow the scope of the potential routes, reducing memory and computation requirements.

Map data can change for many reasons, so map data used for routing must be maintained and updated, usually by the company that shows the maps. The map maintainers also keep track of the Functional Classification of each road segment, with slight variations in definitions at the lower levels:

- FC1 – Interstate or other major highways
- FC2 – Other arterial highways
- FC3 – Collector roads (US Department of Transportation, 2000)
- FC4 – Local roads – higher volume
- FC5 – Local roads – residential and lower volume (Gregory, 2011)

The objective of this information is to try to move smoothly from lower-volume (capacity) and lower-speed roads to higher-volume roads, so as not to overload the lower-volume roads. This also helps choose routes more or less appropriate for other vehicles such as bicycles.

Route Finding Parameters and Constraints

As noted previously, the definition of best route will vary amongst users, and will depend on time, weather, preferences, and many other factors. Parameters used in assessing best route before presenting options to the user include shortest distance, shortest travel time, most cost-efficient, most environmentally friendly, etc. (Intellias, 2022).

Among the many fine-grained details, thorough route-finding requires knowing exactly where the user wants to start and finish. A university campus, for example, may have dozens of buildings and many parking or drop-off locations, and just knowing the address of a building may not be enough to get to the right place for visitors, students, or staff to park.

Road information also includes other dynamic data, collected from a number of sources, but often from the users' communications back to the mapping service. These include actual speed at a particular point, road conditions, weather, accidents, and the like. Services like Google's Waze invite users to submit information about traffic situations to allow more responsive route adjustments.

Other data (both static and dynamic) that may be captured and used by map routing algorithms include a variety of items, as noted in Table 1, below.

Business Use of Online Maps and Routing
While billions of individuals use online mapping and route finding apps world-wide, there is ample business use as well (Wylie, 2024). For example…

Logistics and Transportation
Route optimization is the process of finding the fastest and most cost-effective way to deliver products to customers. Cost savings are generated by shorter distances and travel times, with corresponding reductions in fuel consumption, wear and tear on vehicles and associated maintenance. Optimized delivery routes lead to on-time delivery, resulting in improved customer satisfaction.

Category	Examples
Type of transit	car, public transit, two-wheel motorized, bicycle, walking
Weather	Sandstorms Floods Snow, ice
Road work	Planned Emergency
New roads and routes	Planned Emergency or temporary
Changes to speed limits	Temporary Permanent
Accidents	Severe, causing lane or route closures Moderate, causing delays
Traffic	At route planning As the trip progresses Live data Historical data
Viability of road vs. vehicle	Dirt roads, wet conditions, etc.
Side effects of routes	Environmental impact Scenery Tolls Fuel costs Business traffic impact – pro or con Neighborhood traffic impact
Avoiding things	Highways Tolls Ferries Mountain passes

Table 1: Additional parameters to consider (Google Inc., 2022)

Ride-Hailing Services
Real-time navigation combines historical travel times for routes with real-time traffic conditions leading to a reduction in travel time and fuel savings, benefiting both drivers and passengers. Online mapping and route-finding apps that use real-time navigation can provide precise estimated times of arrival (ETA) of drivers as well as the final destination. Similarly, identifying the best driver for a passenger – the one closest who can arrive quickest – can be achieved in the very same way.

Public Transportation
Many transit agencies leverage online mapping and route-finding systems – sometimes embedded within their own apps – to aid customers as they plan the best routes for where they want to go.

Travel and Tourism
The common features of online mapping and route-finding apps provide tourists with valuable tools. Directions can be provided for driving, walking, public transportation, and cycling. Underlying search engines help users locate nearby restaurants, hotels, etc. Different views like street, landscape, and earth give travelers an introduction to unfamiliar locations.

Delivery Services
Delivery services require the same degree of efficiency and effectiveness of route planning/optimization that other industries do (above). In this case, successful deliveries lead to cost savings and increased customer satisfaction.

Retail and E-commerce
Store locators are a critical component of retail and E-commerce companies' web and app presence. They provide important information to existing and potential customers, such as location(s) and directions leading to an increase in website traffic and customers in stores.

Event Planning
Event planners frequently publish client events online and they often enhance event websites with dynamic mapping and direction capabilities facilitating guest navigation.

Service Call Businesses
Organizations that provide on-site services to businesses or consumers may utilize mapping and route optimization to deal with their unique challenges. This includes the logistical and routing complexities of getting the right people, with the right tools and supplies, to the right place at the time promised. It may also involve alerting the

customer to changes in schedule based on traffic, prior job completion time, etc.

Customized optimizations
Various map vendors provide tools to allow businesses to customize their route planning. This may include route restrictions for certain vehicle lengths, number of axles, vehicle weight, and other factors, such as avoiding left turns. Some of these are simply consumer tools, whereas others are commercially-focused tools, with specialized capabilities aimed at the business market.

Online Maps as a product
Like many other free (as in not charging an explicit fee) services, users would be wise to recognize that maps and routes are products in and of themselves. As such, the map provider needs to consider ways to monetize their map presentations. Such mechanisms may include advertising to prioritize what appears on user map displays, as well as fees for the use of mapping services to find office or store locations, plan travel routes, or other activities appropriate to a business' operation.

Organizational stakeholders and stakeholder groups
Note that many stakeholders have an interest in the delivery of mapping and routing services. Users want good directions and meaningful, relevant information on the map. Businesses along the route want visibility for their services. The map provider is interested in gathering data from map users, and in selling advertising exposure. Public services agencies are interested in travel safety and efficiency. And individuals living or working along the routes are interested in keeping appropriate levels of traffic in their areas, and defending against excessive traffic loads. As such, each stakeholder or group may press the map providers to take steps to meet their specific needs, possibly at the expense of other stakeholders' needs. This presents a challenge for map providers to balance all of these needs against its own interests as well.

3. DISCUSSION SCENARIOS

The following scenarios may be assigned by your instructor as individual or group exercises. Each is designed to be self-contained, so you could analyze any one scenario on its own, and from either a technical level or an organizational level.

Scenario 1 – Off the highway and into the desert!

Picking up from the Opening Story above, Helen was assessing the online map routing suggestion to go off into the desert. As she approached the exit, she had the good fortune to be able to see ahead. I15 was still moving, but slowly. The exit onto the detour was moving well. However, there was a long line of cars coming slowly down to the I15 from that same detour – why? She had only about 30 seconds to decide. She thought those cars coming off of the detour could be a queue of vehicles coming southeast from Las Vegas.

Google Maps had saved her time before, so she decided to risk it. As she motored north, away from I15, she passed a solidly packed, barely moving line of vehicles coming south. About 1.5 miles off I15, a southbound driver flagged her down, suggested she turn around, and reported that "the road is closed up there; you will either get stuck or have to join the line further back."

She promptly headed back to I15. The entire time she was returning from the detour to I15, she continued to see groups of cars coming up from I15. She does not know what prompted those folks to try the detour, or when or even if Google Maps stopped recommending that detour in that time period.

Others were not as lucky. News reports from the following days indicated that thousands of vehicles had taken these routes, and some of the earliest to try the detour drove well past their vehicle capabilities, with at least one needing to call a tow-service to recover their broken vehicle, and reporting that for part of the detour they were driving only 2-3 mph due to the dirt road's poor condition.
Questions

- What data would you expect Google Maps to have available that might have enabled them to detect this problem and stop sending people over this detour?
- What are the risks of using this information to disqualify or downrate alternative routes?
- Where could Google or other map vendors obtain such data?
- What were the key factors that led Helen to take the detour despite potential risks?
- What role could social media play in providing timely updates to travelers during emergencies like this?
- How might real-time weather updates and/or social media data improve detour

suggestions
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 2 – A Winter Wonder Land?

Issues that arise while using online maps and navigation apps can be irritating, causing unnecessary delays. Winter storms can make these challenges much more problematic and dangerous.

Consider the following headlines and the summaries of their associated articles.

"Drivers Say Google Maps Failed Them in Snowstorm"
Drivers complained that when highways were closed due to record-breaking snowfall, services like Google Maps and Waze sent them on hazardous detours through mountain passes. Crystal Kolden tweeted about one such route, saying "This is an abject failure. You are sending people up a poorly maintained forest road to their death in a severe blizzard." No deaths were reported, though one family from Southern California was stranded for two hours when their vehicle got stuck on a snow-covered dirt road. They had ignored illuminated warnings signs and followed GPS instructions instead. Caltrans spokeswoman Raquel Borrayo said that people using mapping apps to dodge closures can face "precarious and dangerous situations with unplowed roads, heavy amounts of snow, and zero cellphone service" (Quinn, 2021).

"Google Maps Sending Drivers To Unmaintained Dirt Roads During Blizzards"
Every winter, the Sweetwater County Sheriff's Office regularly rescues people stuck on unmaintained seasonal dirt roads. "The drivers did not intentionally seek them out, they were guided there," said Jason Mower, Sweetwater County's public affairs director. "Each was mistakenly misled to the same remote roads thanks to their in-car GPS navigation systems." It has gotten so bad that the county had to close roads, build fences and make signs that say, "Your GPS is wrong. This road is closed!!" (Orr, 2023).

"Washington police urge caution against using Google, Apple Maps detours onto remote forest roads"
With all main highways across the Washington Cascades closed due to heavy snow and dangerous travel conditions, Washington State Patrol troopers are warning drivers not to attempt to find their own way over the mountains on forest roads. Sgt. Darren Wright said that asking popular GPS navigation mapping programs to plan a route could send you on a dangerous detour to seldom-traveled forest roads that are not designed for regular vehicular traffic. "We really discourage this idea for safety reasons." (Sistek, 2022).

Questions
- Given these criticisms of two different map and navigation apps, what recommendations for improvement might you suggest to their product owners? Consider technological approaches as well as internal-to-the-company processes.
- What additional steps might the various agencies take – both technological and procedural – to prevent travelers from endangering themselves under these sorts of circumstances?
- What strategies can be employed to improve road infrastructure and signage to prevent drivers from relying on potentially dangerous routes suggested by online map providers?
- Can you suggest a user interface design change that might help users better assess the risks of a proposed detour in adverse weather?
- Most information systems are built with redundancy, to guard against isolated failures and keep operations (driving, in this case) moving. What actions can users take if their mapping app fails or tries to send them into a dangerous area or route?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 3 – A Letter from Pakistan

Ayla is an undergraduate student in Lahore, Pakistan. She writes, sharing her experience with online map and navigation apps.

But first, a bit of background. Lahore is the capital and largest city in the Punjab province. It is the second largest city in Pakistan, with a population of over 13 million people (Government of Pakistan, 2023).

Like many metropolises, Lahore struggles with traffic challenges. Congestion is a major problem, particularly during peak hours. Numerous reasons have been identified, key among them:

- Rapid economic growth causing increased migration
- Insufficient public transportation
- Ineffective urban management
- Inefficient road engineering, e.g., choke points where three and four lane roads collapse into a single lane
- Increased traffic accidents

In her letter, Ayla highlighted two traffic issues unique to Lahore:

VIP Movement
It is very common for government parties to travel in multiple cars, followed by security in separate cars, leading to road closures, traffic jams and blocked vehicles from being rerouted. Ayla has first-hand experience in this regard. Many of the gates to her housing complex are closed when a VIP's family visits another house in the same complex. She often has to take a longer route to exit the complex and get on the main road.

Sinkholes
Rain frequently causes sinkholes to appear, often underneath important and well-travelled roads (Our Correspondent, 2023).

While there are many online map and navigation apps available in Pakistan, Google Maps is the go-to app, as it is world-wide (Anonymous, N.D.). And, as elsewhere, there are the common benefits along with various challenges, such as:

- Maps outdated in various locations
- GPS connectivity issues
- Traffic information not up to date
- Inaccurate directions due to road closures, construction, etc.

Ayla and her friends regularly use GPS systems like Google Maps. It is not uncommon for them to find that new locations or road renovations are not updated on the app, causing them to drive over unpaved roads, be blocked by construction sites, and get stuck in traffic for 2-3 hours when the trip could have been 15 minutes.

Questions

- What additional factors might make Pakistan's roads (or any given city's roads) more subject to this type of congestion?
- What additional information, or perhaps information delivered in a timelier fashion, could improve route-finding in the presence of VIP convoys?
- Beyond their use of map and navigation apps, what information systems might Ayla and her friends use to avoid the "pop up" / unplanned traffic challenges?
- What role does cultural context play in the effectiveness and adoption of online mapping services in different regions?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 4 – Business impacts of online mapping

Brian, a seasoned transporter of edible oil, embarked on a crucial delivery from Uganda to Nairobi. This was a return trip from the manufacturing plant to the distribution center. Before he embarked on his journey, he received a permit from the Kenya Revenue Authority, the national body responsible for collecting taxes as well as providing a GPS tracking device for his cargo.

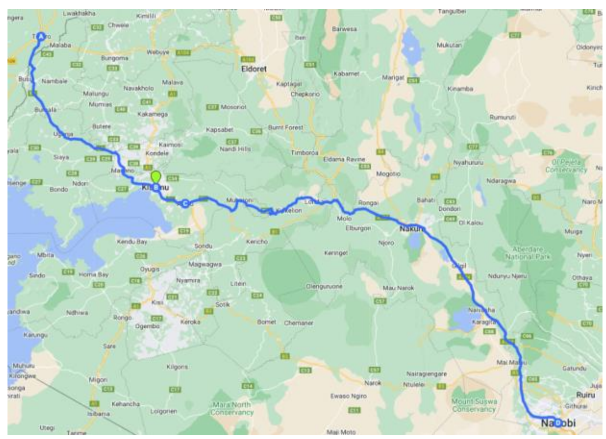

Figure 3: Uganda to Nairobi

The journey began early in the morning with Brian leaving Uganda with a tanker full of edible oil bound for Nairobi. His route, passing through the lush landscapes of Uganda, across the border, and through Kisumu (see Figure 3 – letter B, green pointer), was well-trodden and familiar. Brian's GPS indicated clear roads ahead, and he was on schedule to make a timely delivery.

However, as he approached Ahero (Figure 4, letter C), a small town near Kisumu, Brian encountered an unforeseen challenge: the Ahero bridge was heavily flooded due to recent torrential rains causing the River Nyando to break its banks. Local authorities had closed the bridge to all traffic, and a long line of vehicles had already formed on either side (Obiero, 2024). The flooded bridge was a critical point on Brian's route, and its closure posed a significant dilemma.

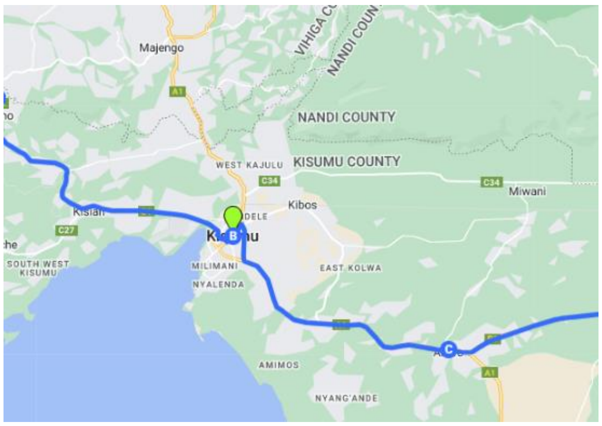

Figure 4: Bridge outage at Ahero (C) above

Figure 5: alternate route (in green) running north of the original route

Faced with this obstacle, Brian had two options. He could wait at the bridge until the floodwaters receded, and the bridge reopened, but there was no clear indication of when this might happen. Delaying his journey could disrupt his delivery schedule, potentially causing financial losses and damaging his reputation. The other option was to take an official detour (see Figure 5, green route), a route that would bypass the flooded bridge but attract a substantial fine of KES 10,000 (about US$80, or between 15 and 30% of his monthly salary) for deviating from the main route. Given that he was on a tight budget since he had spent most of his earnings to repair the chassis of the lorry, the second option was daunting.

Questions

- How could Brian possibly have avoided running into this dilemma? Is there other information that might have helped him or the map services make better choices?
- Why is it hard to forecast bridge closures amid weather issues?
- How might the processes for issuing permits and managing transport routes be improved to account for unexpected events such as natural disasters?
- What strategies can be implemented to support transporters financially when they face penalties or additional costs due to unavoidable detours or route changes?
- How can technology solutions be designed to provide contingency routing for critical business deliveries in cases of unexpected road closures?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 5 – GPS Spoofing

At a coffee shop in Beirut, Maya (not her real name) was reviewing possible matches on Bumble. Usually matches were located in Beirut. But in the recent past, since the onset of the Israel-Hamas war, most matches were far away – in Israel (Arraf, 2024).

Taxi drivers throughout Lebanon have not been able to trust directions on their smartphones because their online map apps are indicating that they're located in the Beirut airport or Cairo, Egypt (Bulos, 2024).

In flight in 2024 from Qatar to Madrid, cruising at 36,000 feet, Víctor (a commercial pilot) received an alert from the cockpit’s GPS system, telling him that he was 1,800 feet from the ground. He knew this was incorrect, but he had never experienced such an alert in his 33 years of flying (Inal, 2024).

The common thread? They are all being affected by the Israel Defense Force’s use of GPS spoofing to counter missile strikes from Hamas and its Lebanese ally Hezbollah who possess GPS-guided weapons, including drones. In an April news conference, Israeli military spokesman Rear Admiral Daniel Hagari said “we are aware that these disruptions cause inconveniences, but it is a vital and necessary tool in our defensive capabilities.” (Bulos, 2024).

GPS spoofing exploits vulnerabilities in GPS infrastructure; in particular, the weak signal strength of GPS satellites. The Global Positioning System sends signals from satellites to GPS receivers, such as smart phones and commercial airliners. Receivers calculate their position based on the time it takes for the signals to arrive. Due to the weak signal strength of the GPS satellites, their signals can easily be overwhelmed by fake signals, leading to inaccurate location data on the receiving devices (McAfee Inc, N.D.).

While incorrect locations in a dating app are a nuisance and delays for taxi drivers can lead to customer dissatisfaction as well as a reduction in fares as they take time to figure out directions, the risks to commercial airlines are more serious. Researchers at the University of Texas have estimated that more than 50,000 flights have been spoofed in the Middle East in 2024 (Gebrekidan, 2024).

When pilots realize that their GPS receivers are being spoofed, they are often instructed to shut down their plane's GPS receiver and dependent components like the terrain warning system. In these circumstances, pilots will resort to other means for navigation, such as referring to location points on the ground. This frequently causes pilots to ask air traffic control for assistance, which can prove challenging for already stressed air traffic controllers.

With this in mind, Todd Humphreys, an aerospace engineering professor at the University of Texas said "There's no question that safety has been reduced in flights in the eastern Mediterranean because airlines are instructing their pilots to shut off GPS" (Bulos, 2024).

Questions

- Separate from the politics of the situations, what steps could be taken to prepare for such a scenario?
- What are the potential impacts of a breakdown of GPS service?
- What are the ethical considerations surrounding the use of GPS spoofing for military purposes? How do we balance national security needs against potential civilian risks?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

Scenario 6 – What's in a name?

The goal was simple. Barbara and Paul were in Germany, and Barbara wanted to see the small town where her mother's family had lived during the Second World War.

They were in Nuremberg when they began their search. They had a couple of clues. The name of the town is Jettingen, and many of Barbara's extended family – her mother, aunts, uncles and cousins – had stayed at one point during the war at an old castle that has since been converted to a hotel named Sindlingen.

Paul searched Google Maps for Sindlingen and initially found a neighborhood by that name near Frankfurt, but no hotel. Paul found it easier to use a German travel app – DB (Deutsche Bahn, German Rail) Navigator; in particular because Google Maps does not cover long-distance train travel as thoroughly as DB Navigator does. Paul searched for Jettingen on DB Navigator and found a match. They booked two tickets for the 2+ hour train ride and headed out.

When they arrived, they found themselves at Jettingen-Scheppach (the yellow map markers at bottom center of Figure A), and soon discovered that this was not where they wanted to be. It turns out that the DB Navigator app displays this location simply as Jettingen. They happened upon two immigrant Polish workers who explained that same-named towns are frequently distinguished by the addition of a modifier such as a state name or postal code. These good Samaritans further explained that Barbara and Paul were about 150 kilometers away from where they wanted to be in Unter Jettingen (B, with green map markers, lower left in Figure 6), which is about 45 kilometers outside Stuttgart.

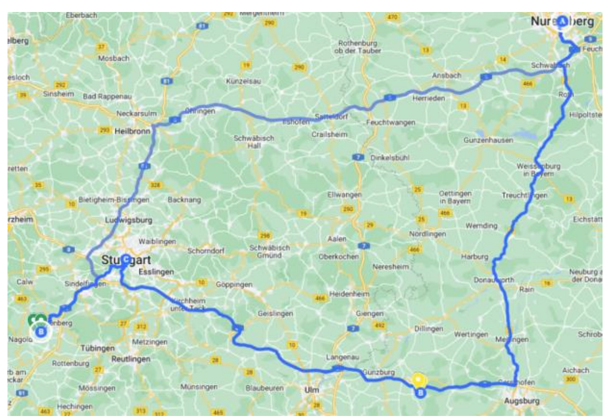

Figure 6: Routing errors in finding a German castle/hotel

Paul tried to book this leg of the trip with Uber and Bolt (a European Union ride-hailing company); both companies responded with "sorry, an error has occurred," meaning that no drivers would take the ride. So, onto a train for the ride to Stuttgart, and an Uber ride to Unter Jettingen. They made it to the Hotel Schloss

Sindlingen in the evening. Goal accomplished, all in one eventful day.

Questions

- What value or additional information could a user get by comparing results from two independent mapping services?
- How can one best distinguish between two similarly- or identically-named places?
- What features could be added to map services to help users disambiguate between similarly named locations?
- Try a search for Jettingen in map services other than Google Maps. How do those services help differentiate between the various places with similar or identical names?
- What other questions or observations can you make about this scenario as it relates to the principles of online mapping and route-finding?

4. ADDITIONAL RESEARCH QUESTIONS

Please feel free to use these prompts as you and your instructor see fit, to conduct additional research and analysis on online mapping and route-finding issues.

Added Risks in Autonomous Vehicles

Autonomous vehicles are already in limited service in various parts of the world. Considering your own experience as a driver, what do you anticipate might be new problem areas to explore and resolve if the rider in the vehicle has no means to control route decisions? What data might be used to resolve those?

Side effects of GPS and routing systems' impact on traffic

Personal experiences and numerous media reports indicate sometimes-significant impacts on traffic in certain areas. Quiet neighborhoods can suddenly become an alternate route for a major nearby road, or autonomous vehicles can suddenly divert onto a side street, and then have to turn around (Macfarlane, 2019).

Research some incidents of this type of impact. What were the underlying causes of the impact? What additional information could have been used (or better used) to mitigate this effect? What are the ethical trade-offs to mapping companies using this excess capacity of the road system for helping commuters, but overloading those quiet roads and disrupting travel for the local citizens? Are there ethical ways to block these route impacts? (e.g., Limer, 2016)

Impacts of the Technology Acceptance Model for online maps

Revisit Scenario 2 above and assemble your product team to further discuss these recent events and assess the impact. Please use the conceptual Technology Acceptance Model below to first assess and discuss the impact – how will this event affect those directly and indirectly impacted in terms of their intention to use Google (or perhaps other) online mapping services going forward? Be sure to consider each variable as well as the interrelation with the other variables.

A premise of this model is that the more functionality available, the more likely the user will be to use and adopt online mapping software (Marzuki et al., 2016). Given this, what specific recommendations would you make to enhance the functionality and features from a product perspective. Consider technology options, crisis communication features, and the other Ps in relation to the product enhancements (Price, Place/Distribution, and Promotion). Be prepared to present your recommendations to senior management with a high-level timeframe for implementation.

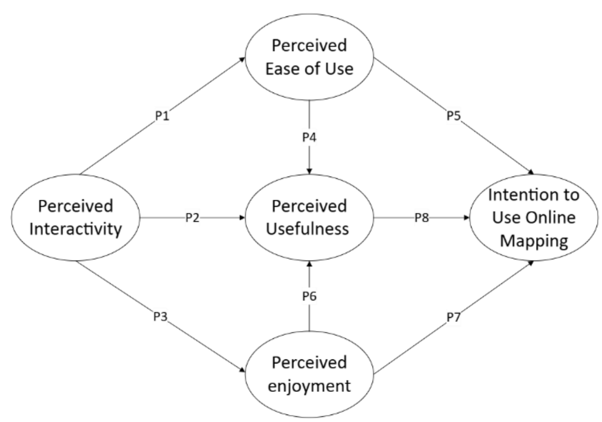

Figure 7: Technology Acceptance Model (TAM) Conceptual Framework Adding Perceived Enjoyment Variable (Marzuki et al., 2016)

Testing Map Services by Manipulating the Environment

A performance artist in Berlin, Germany, borrowed mobile phones from 99 friends, and set them all up to be running Google Maps directions.

He then loaded them into a wagon that he pulled behind him as he walked through Berlin and across a bridge. This had the effect of convincing Google Maps that there was a terrible traffic jam there, and it showed that on the live map and re-routed other (real) traffic to other bridges (Barrett, 2020).

- Can you think of other ways to test or stress an online mapping system to see if you can trigger or exploit certain online mapping or route-finding behaviors?
- What are the legal and ethical concerns to be considered before actually conducting such an exercise?

Comparing various map services

There are a wide variety of online map and routing tools available to explore at no cost. Pick three that are relevant to your area, or are otherwise interesting to you, and request each to give you directions from one place to another. You might also try seeing how they respond to general vs. specific destinations, e.g., Phoenix Airport vs. Terminal 1 at Phoenix Airport, Short term parking. If you have access to a vehicle with a built-in GPS, its results would be interesting as well.

- How were the maps different from one another? What was similar or identical about them? Did the time estimates match?
- Why do you think the results differed?
- Try the directions using other travel media (public transit, walking, etc.). How does that affect the results?

5. CONCLUSIONS

We hope that this case provides significant opportunities for students to consider how online maps and routing decisions work, and the data required to make the “best” decisions. Information is fundamental to making good decisions in any situation, and especially so in routing decisions, with a wide range of potential considerations and consequences.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

Anonymous. (N.D.). Best Navigation Apps In Pakistan. *Hamari Web*. Retrieved from https://hamariweb.com/mobiles/gadgets/best-navigation-apps-in-pakistan_102808

Arraf, J. (2024). Israel fakes GPS locations to deter attacks, but it also throws off planes and ships. *NPR*. Retrieved from https://www.npr.org/2024/04/22/1245847903/israel-gps-spoofing

Barrett, B. (2020, Feb 3). An Artist Used 99 Phones to Fake a Google Maps Traffic Jam. *WIRED*. Retrieved from https://www.wired.com/story/99-phones-fake-google-maps-traffic-jam/

Bulos, N. (2024). Israel’s ‘GPS spoofing’ tricks missiles, but also commercial airplanes, dating apps in Mideast. *LA Times*. Retrieved from https://www.latimes.com/world-nation/story/2024-07-09/israel-gps-spoofing-attacks

DuBose, J. (2023, Nov. 28). Google apologizes for sending SoCal-bound drivers on road to nowhere. *KTLA 5*. Retrieved from https://ktla.com/news/local-news/google-apologizes-for-sending-drivers-on-off-road-detours-between-l-a-and-vegas/

Gebrekidan, S. (2024). An Israeli air base is a source of GPS ‘spoofing’ attacks, researchers say. *NY Times*. Retrieved from https://www.nytimes.com/2024/07/03/world/europe/an-israeli-air-base-is-a-source-of-gps-spoofing-attacks-researchers-say.html

Google Inc. (2022). Google Maps Platform - Maps Javascript API - Directions Service. Retrieved from https://developers.google.com/maps/documentation/javascript/directions

Government of Pakistan. (2023). *TABLE 1 : HOUSEHOLDS, POPULATION, HOUSEHOLD SIZE AND ANNUAL GROWTH RATE*. Retrieved from https://www.pbs.gov.pk/sites/default/files/population/2023/Punjab.pdf

Gregory, K. (2011, December 18). How a GPS Calculates Routes. Retrieved from https://blog.kdgregory.com/2011/12/how-gps-calculates-routes.html

Inal, K. (2024). How electronic warfare is affecting civilians and aviation. *ABC News*. Retrieved from https://abcnews.go.com/US/electronic-warfare-affecting-civilians-aviation/story?id=109895516

Intellias. (2022, August 29, 2023). Unravelling Real-Time Route Optimization: New Ways to Solve Vehicle Routing Problems. Retrieved from https://intellias.com/real-time-route-optimization/

Limer, E. (2016, June 6). How Neighborhoods Are Fighting Off Traffic That Waze Sends Their Way. *Popular Mechanics*.

Luxen, D., & Vetter, C. (2011). *Real-time routing with OpenStreetMap data.* Paper presented at the Proceedings of the 19th ACM SIGSPATIAL international conference on advances in geographic information systems.

Macfarlane, J. (2019, September 24). Your Navigation App Is Making Traffic Unmanageable. Retrieved from https://its.berkeley.edu/news/your-navigation-app-making-traffic-unmanageable

Marzuki, M. I. I., Rosly, A. N., Roslan, N. S., Abdullah, D., Kamal, S. B. M., & Azmi, A. (2016). The role of perceived interactivity, perceived ease of use, perceived usefulness, and perceived enjoyment toward intention to use online mapping service applications. *International Academic Research Journal of Business and Technology, 2*(2), 135-139.

McAfee Inc. (N.D.). What is GPS spoofing? *McAfee Learn*. Retrieved from https://www.mcafee.com/learn/what-is-gps-spoofing

Obiero, A. (2024). Traffic Flow Restored At Ahero Bridge After Water Levels Reduce. Retrieved from https://www.citizen.digital/news/traffic-flow-restored-at-ahero-bridge-after-water-levels-reduce-n341580

Orr, J. (2023). Google Maps Still Sending Drivers To Unmaintained Dirt Roads During Blizzards. Retrieved from https://cowboystatedaily.com/2023/01/23/google-maps-still-sending-drivers-to-unmaintained-dirt-roads-during-blizzards/

Our Correspondent. (2023, July 24). Sinkholes disrupt city traffic. *The Express Tribune*. Retrieved from https://tribune.com.pk/story/2427641/sinkholes-disrupt-city-traffic

Quinn, R. (2021, December 31). Drivers Say Google Maps Failed Them in Snowstorm. *Newser*. Retrieved from https://www.newser.com/story/315113/drivers-say-google-maps-failed-them-in-snowstorm.html

Sistek, S. (2022). Washington police urge caution against using Google, Apple Map detours onto remote forest roads. *FOX Weather*. Retrieved from https://www.foxweather.com/weather-news/washington-police-urge-caution-against-using-google-apple-map-detours-onto-remote-forest-roads

US Department of Transportation. (2000). *Road Function Classifications*. Washington, DC Retrieved from https://safety.fhwa.dot.gov/speedmgt/data_facts/docs/rd_func_class_1_42.pdf

Wylie, L. (2024, January 8). Navigation App Revenue and Usage Statistics. *Business of Apps*. Retrieved from https://www.businessofapps.com/data/navigation-app-market

Student Perceptions of Learning through Original and AI-Generated Python Programs from a Software Quality Perspective

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Abstract

This study explores student perceptions of learning to code by evaluating AI-generated Python code. In an experimental exercise given to students in an introductory Python course at a business university, students wrote their own solutions to a Python program and then compared their solutions with AI-generated code. They evaluated both solutions using a software quality assessment framework, focusing on the correctness, efficiency, understandability, consistency, and maintainability, which provided a guide to evaluating code beyond simply correctness of the solution. Research examines how students perceive and utilize generative AI, considering their motivations, outcomes, and experiences. Findings suggest that while students see significant potential in using AI tools to enhance their coding process and appreciate the efficiency and compactness of the AI-generated code, they often prefer their own solutions due to familiarity and features used. This research aims to inform future studies on student application of AI tools in learning to code and provides educators with a model for evaluating AI's impact on student learning.

Keywords: Python, Coding, Generative AI, Software Quality Assessment

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Student Perceptions of Learning through Original and AI-Generated Python Programs from a Software Quality Perspective

Mark Frydenberg, Anqi Xu and Jennifer Xu

1. INTRODUCTION

Learning to code is an important skill for future business professionals (code.org, 2024; Shein, 2014) and introductory students often find it challenging to master a programming language as well as develop the critical thinking skills necessary to assess the quality of their code. The arrival of generative artificial intelligence (AI) introduced large language models such as ChatGPT, Microsoft Copilot, and Google Gemini, which are capable of writing code in multiple programming languages.

This paper explores student perceptions of learning from AI-generated Python programs. The authors describe a study where students enrolled in an introductory Python course at a business-focused university first solved a programming exercise on their own and then compared their solutions with code generated by AI tools.

The instructors presented Boehm's software quality assessment framework (Boehm et al., 1976) in class and discussed the various criteria (correctness, efficiency, understandability, consistency, and maintainability of the code) that they would use in evaluating Python code solutions to this assignment. By examining how students perceive and utilize generative AI, focusing on their motivations, outcomes, and experiences, this research can inform future studies on the use of AI tools by students learning to code and provide educators with a model for evaluating its impact on student learning.

As students continue to use AI platforms as learning support tools, these research questions arise:

RQ1: How do students perceive learning from code they write themselves compared to code generated by AI?

RQ2. How can students use principles of software quality (correctness, efficiency, and readability) to assess and compare their own code with code generated by AI tools?"

2. LITERATURE REVIEW: STUDENT PERCEPTIONS ON THE USE OF GENERATIVE AI IN COMPUTING EDUCATION

Since ChatGPT and other generative AI models first emerged in November 2022, educators have been exploring ways to integrate them as learning tools in the computing classroom (Denny et al., 2024; Ma et al., 2024). Large language models "are now capable of producing code automatically and have demonstrated impressive performance on problems that are typical in introductory programming courses (Denny et al., 2024, p. 296)." For students learning to code, using AI can be a temptation (to get the correct answers on demand) as well as a tool to better understand their own solutions.

Recent studies on student perceptions of AI in coding courses have found that students are concerned about the validity and accuracy of results produced (Chan & Hu, 2023; Zastudil et al., 2023; Zhang et al., 2024), and on becoming dependent on those results to succeed. "One of the main issues is over-reliance on AI, which may hinder people's growth, skills, and intellectual development over time (Aruleba et al., 2024, p. 11)."

Although concerns about academic integrity, plagiarism (Chan & Hu, 2023; Tala et al., 2024), and data privacy have been increasing due to the personalized and immediate support that generative AI platforms provide, using AI tools can also promote creativity and assist in brainstorming new ideas (Ma et al., 2024; Tala et al., 2024), and knowing how to use AI properly can help with employability (Feldman & Anderson, 2024).

In a study of graduate and undergraduate economics students, Tala et al. (2024) explored perceptions of generative AI tools and found that "students with more advanced digital skills are more inclined to use AI for content generation. (Tala et al., 2024, p. 83).”

Instructors are finding new ways to incorporate generative AI tools into their classes (Choudhuri et al., 2024) and those which are most successful have students use AI’s output as the basis for further problem solving (Zhang, et al., 2024).

One study (Ma et al., 2024) explored how beginning students perceived using ChatGPT to learn how to code in Python. They used ChatGPT as a programming partner, asking for help with concepts, code verification, and debugging and optimizing their code. Students found that the explanations from ChatGPT were helpful in explaining concepts and debugging code, but consistent with other results, were concerned about over-reliance on AI tools.

In a study regarding how students in an introductory Java class perceive feedback generated by AI platforms (Zhang et al., 2024), students received AI-generated feedback about their code. One version included the code in the prompt, the other did not. Students evaluated the feedback provided to determine whether AI having access to their solutions impacted the quality of the feedback provided. They found that when AI analyzed their code, the feedback was more useful.

Many students will provide the description of a problem as it appears in their assignment or textbook, directly to generative AI platforms with the hope of obtaining code that solves the problem, but this is not always sufficient to obtain results that align with what is taught in the classroom. AI tools often generate code using programming constructs that students may not have learned yet. Recognizing that “the ability to engineer effective prompts is now an essential skill for computing students (Denny et al., 2024, p. 297),” they introduce “Prompt Problems,” an exercise where students solve programming problems by formulating natural language prompts which guides AI platforms to generate code to solve the problem.

The following perceptions emerged from our literature review on the use of generative AI tools in computing education:

Generative AI tools can:

- give useful, personalized feedback when reviewing student’s code
- provide helpful feedback when debugging code
- be helpful when checking homework
- confuse students by providing solutions that do not align with concepts taught in class

Students are most concerned about:

- knowing or being able to determine if solutions from generative AI are complete and accurate
- relying on generative AI too much
- academic integrity

3. METHODOLOGY

This study involved 81 participants from six sections of CS 230, an introduction to programming with Python course at a New England business-focused university. CS 230 is an elective course for CIS majors and minors, and a required course for data analytics and AI majors. Of the 81 participants, 54 completed the survey at the end of the study. The course materials, assignments, and quizzes were common among all sections, which were taught by four different instructors during the Fall 2023 semester. Students voluntarily participated and received extra credit points toward their course grade for their participation. Quizzes were administered during weeks 5 and 10; this extra credit assignment was offered during week 13, so students had an opportunity to complete it already having a good idea of their standing in the course. Students may have (and likely) used generative AI tools earlier in the course, but if so, it would have been on their own, as the instructors did not permit the use of AI tools to complete earlier assignments.

The instructors provided a programming problem for students to complete (see Appendix A) that was modeled after a programming assignment they completed earlier in the semester. The problem was designed in a way that the solution could either be implemented using several basic decision statements (various forms of if/else and if/elif/else) or using more efficient data structures (e.g., lists and dictionaries) to manage the data and logic of the program. We expected students to use more advanced approaches given that the assignment was presented at the end of the semester and had no restrictions on coding constructs that could or could not be used. Students had one week to write their own solution and then use AI tools to generate a solution to compare. Because this assignment took place at the end of the semester, it served as a capstone opportunity for students to evaluate code written by another (in this case, AI), applying any knowledge and skills developed throughout the course.

Students were asked to evaluate their own code and the AI-generated code based on five software quality elements (Boehm et al., 1976) and then make an overall assessment of their approach versus AI's approach to solving the problem. See Appendix D for one student's dialogue with ChatGPT and analysis comparing their code with AI-generated code.

Software Quality Assessment

Software quality can be assessed from many different perspectives using various metrics. In a seminal paper, Boehm et al. (1976) identify eleven quality indicators of computer programs, including understandability, completeness, conciseness, portability, consistency, maintainability, testability, usability, reliability, structuredness, and efficiency. The quality of software is directly affected by the quality of these individual program components.

As software has been increasingly complex, the number of quality indicators has also grown significantly. Based on an extensive literature review, a more recent study compiles an inventory of 48 software quality metrics, which are grouped into six dimensions: functionality, reliability, usability, efficiency, maintainability, and portability (Miguel et al., 2014).

Since the project in our course involves students creating one Python program whose solution can be implemented in about 100 lines, we have selected five quality indicators for students to consider when evaluating their code and AI-generated code.

The authors felt that these metrics were the most relevant to the assignment, and the most accessible to beginning coding students. In the assignment description, we provided students with the metrics and exemplary questions summarized below to guide their analysis:

<u>Correctness/Completeness:</u> Does the program provide all the correct output given the input?

<u>Efficiency:</u> Are the data about the application (e.g., pricing information) maintained using efficient data structures? An efficient data structure can reduce the use of control structures (e.g., loop and if statements).

<u>Understandability/ Conciseness:</u> Is the program easy to read and understand? Is it long and overly complicated? Are comments included and helpful? Is the program so concise that it is hard to understand?

<u>Consistency:</u> Is the program consistent in its use of naming variables, indentation, and formatting?

<u>Maintainability/Structuredness:</u> A program is maintainable if it is modular, does not duplicate steps, and is written in such a way that if business circumstances change, updates to the code to reflect those changes are minimal. For example, does the solution break the problem down into smaller modules or functions? If a business decides to change the prices of their products, would that require a change to many lines of code?

The authors felt that using all 15 metrics would be overwhelming to students, so we selected eight and consolidated them to five that were particularly relevant to new coders when evaluating short Python programs. Metrics such as device independence, legibility, and augmentability as described by Boehm et al. (1976) are less applicable to this assignment.

We focused on important skills that novice programmers need to develop, such as how to evaluate whether a solution is correct. The course also tries to teach students to write maintainable code; even in smaller, simpler programs, code must be understandable and concise, so it is easier to modify and debug. Consistency is important so that students learn to write code that is readable, with meaningful variable names so it is self-documenting. Teaching students to write code that is modular and well-structured from the start encourages good programming habits that will be useful later in their studies as their programs become more complex.

These qualities also best align with the course goals and objectives, which include defining algorithmic solutions and designing modular programs to implement those solutions, identifying test cases to test and debug code to ensure it runs properly, and efficiently representing data values using appropriate data structures.

In addition to their written programs and a report evaluating the software quality of their and AI's solutions, students also completed a short survey (see Appendix B) which asked about their experiences using generative AI tools as a partner in learning to code, and the perceived usefulness of the feedback that they received while interacting with generative AI tools.

Empirical Analysis

To address RQ3 regarding factors influencing students' perceptions of AI tools, this study employed an empirical analysis using linear regression. This approach allows us to model the linear relationship between independent variables (factors influencing perceptions) and dependent variable (students' perceptions). In a similar study, Xing and Jiang (2024) use linear regression to analyze factors influencing user experience in AI chat systems. This demonstrates the applicability of using linear regression to understand user perceptions of AI-related experiences. Appendix C shows how the survey questions were coded for this analysis.

Specifically, analysis focused on three key questions in the survey:

- "I found the AI-generated solutions to be clear, concise, and relevant to the assignment."
- "I trust the solutions AI-generated to be correct and accurate."
- "Reviewing code generated by AI tools increased my confidence in writing code myself."

These questions served as dependent variables in our analysis, measured by five-point Likert scales ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree").

The regression analysis includes two independent variables: the aggregate scores of students' responses to the five quality dimensions for AI-generated code and for their own code, respectively. Specifically,

$$AIQuality = \sum_{i=1}^{5} QualityForAI_i \qquad (1)$$

$$StudentCodeQuality = \sum_{i=1}^{5} QualityForStudent_i \qquad (2)$$

where $QualityForAI_i$ represents students' responses to the five quality dimensions for AI-generated code including Correctness / Completeness, Efficiency, Understandability / Conciseness, Consistency, and Maintainability / Structuredness.

Similarly, $QualityForStudent_i$ are students' answers to the five quality dimensions for their own generated code. The analysis also includes several control variables:

- $StudentPreference$. This variable represents the student's preference for using AI-generated code or their own code.
- $StudentMajor$. We categorize students' majors as either technology-related or non-technology-related majors.
- $Quiz1$. Students completed two quizzes during the semester. This variable records the score of the first quiz.
- $Quiz2$. Students' score of the second quiz.
- $Gender$. Student's gender.
- $Section$. Students participating in the survey were enrolled in six class sections taught by four different instructors. We include this variable to exclude confounding effects caused by educational differences.

The regression model is provided in Equation (3).

$$\begin{aligned} StudentPerception &= \alpha_0 + \alpha_1 AIQuality \\ &+ \alpha_2 StudentCodeQuality \\ &+ \alpha_3 StudentPreference \\ &+ \alpha_4 StudentMajor + \alpha_5 Quiz1 + \alpha_6 Quiz2 \\ &+ \alpha_7 Gender + \alpha_8 Section + \varepsilon \end{aligned} \qquad (3)$$

4. RESULTS

Survey Findings

Figures 1 and 2 show responses to survey questions asking student opinions on their experience of using AI tools and the impact of generative AI tools on their learning. Responses were measured by five-point Likert scales ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). Students mostly agreed that using generative AI tools was enjoyable, and that they found the results to be clear, concise, and relevant. Concomitantly, most students disagreed that they could trust the AI-generated solutions. This could be because of the complexity of the program they were writing.

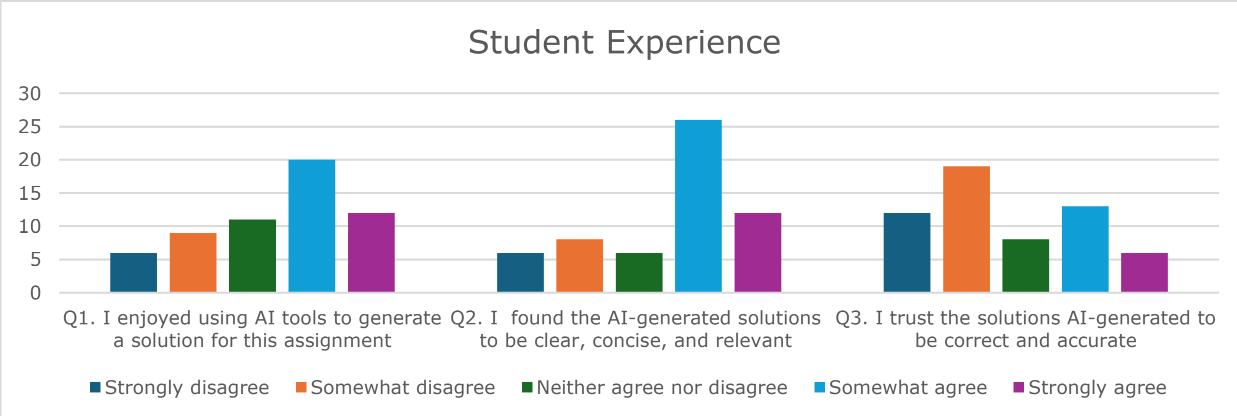

Figure 1. Student Experience with AI

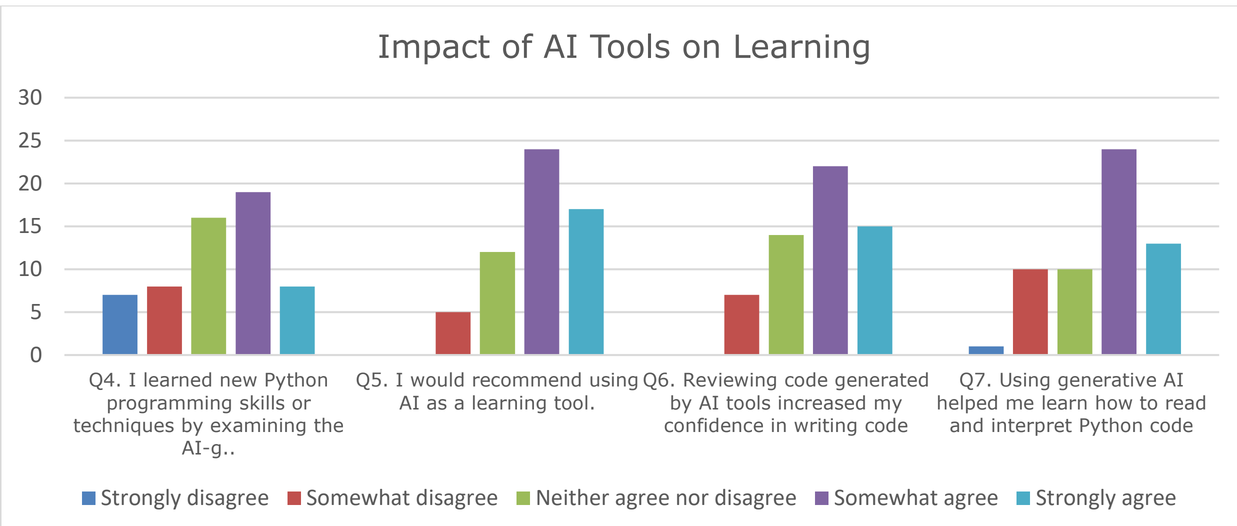

Figure 2. Impact of Generative AI on Learning

As for the impact of generative AI on learning, students generally agreed that they learned new Python skills or techniques, that they recommend using AI as a learning tool, that reviewing AI-generated code increased confidence in writing their own code, and in learning how to read and interpret Python code.

The most popular generative AI tool that students used was ChatGPT (85%), followed by Google Gemini/Bard (6%). Students used Grok (1%), Microsoft Copilot (1%), and other tools (6%) to complete the project.

Empirical Analysis Findings

After removing the incomplete student responses from the 81 participants, 54 valid data points for empirical analysis remained. Table 1 presents the results for the empirical analysis using a linear regression regarding the effects of the independent variable (i.e., the AI software quality and the student-generated code quality) on students' perception of AI tools.

Dependent variables are Clarity, Trust, and Confidence as shown in Columns (1), (2), and (3) of Table 1. Column (1 / Clarity) reports the impact of the independent variables on students' perception of AI tools' clarity, conciseness, and relevance to the assignment based on the survey question "I found the AI-generated solutions to be clear, concise, and relevant to the assignment."

Column (2 / Trust) reports the impact of the independent variables on the extent to which they trust AI-generated solutions, based on the survey question "I trust the solutions AI-generated to be correct and accurate."

Column (3 / Confidence) reports the impact of the independent variables on how AI can help improve students' confidence based on responses to the survey question "Reviewing code generated by AI tools increased my confidence in writing code myself."

Results show that the overall quality of AI-generated code is positively related with students' perception of AI tools' clarity, conciseness, and relevance. In the shaded row, $AIQuality$ has a significant positive relationship to clarity. The value of 0.480 suggests that higher AI quality leads to perceptions that AI solutions are clearer, concise, and relevant. However, the quality of students' own code has no impact on this perception.

Similar results also apply to students' perception of AI tool's correctness and accuracy. A significant positive relationship (0.454, $p<0.05$), indicates that higher $AIQuality$ increases trust in the accuracy of AI-generated solutions.

Dependent Variables: Clarity, Trust, Confidence
Method: Linear Regression
Included observations: 54
Standard errors are in parentheses.

Variable	**(1)**	**(2)**	**(3)**
	Clarity	**Trust**	**Confi-dence**
$AIQuality$	0.480**	0.454*	0.248*
	(0.160)	(0.174)	(0.121)
$StudentCodeQuality$	-0.016	-0.120	0.163
	(0.203)	(0.220)	(0.153)
$StudentPreference$ (AI vs Student)	-0.177	-0.503	-0.433
	(0.481)	(0.522)	(0.362)
$Quiz1$	-0.013	-0.052	-0.035
	(0.044)	(0.047)	(0.033)
$Quiz2$	-0.014	-0.007	0.049*
	(0.027)	(0.029)	(0.020)
N	54	54	54

Notes: *$p < 0.05$, **$p < 0.01$.

Table 1. Empirical Analysis Results

Students also believe that "Reviewing code generated by AI tools increased my confidence in writing code myself." The significant positive relationship (0.248, $p<0.05$) suggests that higher $AIQuality$ boosts confidence in writing code after reviewing AI-generated code. Only $Quiz2$ scores have a small positive impact on confidence in writing code. As Quiz 2 was the more difficult of the two quizzes in the course, this suggests the perception that students who did well on the quiz were more confident that AI tools can further help them improve their code-writing abilities. Results show no significant differences between different sections, genders, or majors, in terms of how clear, concise, and relevant the AI solutions are, on trust in AI solutions, or on confidence that AI can be helpful when writing code.

Qualitative Evaluation

Students noted that several attempts were often necessary to have the AI-generated code produce desired results. One student commented, "The AI was able to get the correct output after a lot of prompting it. Even after a lot of prompting, it was unable to successfully… line the columns up." Additional shortcomings in the AI-generated solutions were related to lack of error handling and validating user inputs.

One student said in his overall assessment:

> "Both the AI-generated code and my manually developed code have their merits. The AI code is notable for its straightforward and clean approach, while my code is distinguished for its modular structure and potentially more efficient handling of user choices. The choice between the two would depend on the specific needs and preferences of the developer or the project. The AI code appears to be a well-rounded solution without the need for significant prompt refinement. It gives a good framework where the user would have a good start. Although it has some errors and some areas made need a bit more tweaking, the overall code seems to have a good start."

This gap between what students learn in the classroom and the often more advanced solutions generated by AI underscores the need for critical thinking skills, as students must be able to evaluate the quality and accuracy of AI-generated code.

5. DISCUSSION

This study focuses on perceived benefits and drawbacks that students have when using generative AI tools to develop code. While we encourage students to use AI tools as part of their learning, equally important is their ability to evaluate the results that AI generates to determine their trustworthiness. In the context of a coding course, this may often involve learning new features or constructs of a language not covered in class, to be able to critically evaluate the output and refine their prompts or the code generated to further develop their own coding skills.

We return to our research questions:

RQ1: How do students perceive learning from code they write themselves compared to code generated by AI?
Both students and instructors agree that AI tools can be a valuable learning tool, and instructors need to adapt their assignments to find ways to integrate these tools into the classroom that develop critical thinking and problem-solving skills.

They see AI tools to supplement and enhance their coding efforts but still recognize the value of being able to write their own original code. Many prefer their own code solutions for some tasks because their code is more familiar and easier to follow, regardless of whether their code is more efficient.

RQ2. How can students use principles of software quality (correctness, efficiency, and readability) to assess and compare their own code with code generated by AI tools?"

The five quality indicators provide guidelines for students to evaluate their code and that generated by AI.

<u>Correctness/Completeness:</u> Students can test both their code and AI generated with various combinations of input values, and make sure that the output values match.

<u>Efficiency:</u> Students can examine both solutions to determine if they use similar approaches to storing data, and if not, try to figure out if one leads to more efficient code than the other. For example, using dictionaries can often reduce the number of lines of code required to represent the same information using if statements and other control structures.

<u>Understandability/ Conciseness:</u> Students can compare both solutions to determine "readability" and the extent to which comments are helpful.

<u>Consistency:</u> Students can review their code for using consistent naming conventions, white space, and other formatting guidelines. While most IDE's automatically indent, and AI tend to produce consistent code that follows standard coding conventions, students can use AI-generated code as a model when evaluating their own code.

<u>Maintainability/Structuredness:</u> Students can modularize their code into different functions, making it easier to maintain, and compare their solution with the AI-generated code.

When evaluating AI-generated code, students can apply their own standards – is the AI-generated code "too perfect?" For example, AI-generated code tends to use long descriptive variable names and includes more comments than most beginning students might write on their own. Students can determine if they are necessary or excessive.

Practical Recommendations for Instructors
The authors recommend that students use a variety of generative AI tools when completing this project to see the differences in results that they generate. The authors also recommend that students examine and test the code that AI generates as part of their evaluation.

After reviewing student submissions, such as the one in Appendix D, in a future iteration of this assignment, the authors suggest that students specifically discuss how their code differed from that generated by AI, and if multiple iterations of prompts to the AI chatbot resulted in more efficient code.

Many students appreciated the efficiency of AI-generated code and noted that it was often more concise than the code they could write themselves. This is often because as beginning coders, it takes practice and experience to recognize when to use Python's advanced features such as terse if and list comprehension to create more concise code.

Students found that for complex problems such as the one assigned, AI-generated code could not always accommodate the many different possible cases for data validation and error handling. Creating assignments with these requirements requires students to examine the code more closely to ensure it meets the requirements.

Boehm's framework to study code is a classic, however, incorporating "security" or "vulnerability" provides a more contemporary perspective for students to consider. While a simple academic example is unlikely to pose direct security threats, students could research and apply secure coding principles such as data validation, running code with the least necessary privileges, and encoding special characters in the output that enterprise applications use to mitigate risk.

Limitations

The authors acknowledge that this study has several limitations. First, it was performed once during the Fall 2023 semester with a group of 81 students from across 6 sections of the course taught by 4 instructors. While all assignments and quizzes were synchronized, variation in teaching style, grading leniency, and class formats exist.

Second, the assignment was offered as optional/extra credit at the end of the semester, so students had different motivations for participating. Students who did not need the extra credit to boost their grades completed it for the sake of learning, while other students may have been motivated to complete the assignment specifically because of the possibility of boosting their grades with extra credit. Making the assignment required of all students (rather than extra credit) is appropriate for a future study to determine if the extra credit factor has any impact on this study's findings and would reduce the possibility of selection bias.

AI Doesn't Know What Students Know

A challenge of AI-generated solutions is that they often incorporate coding concepts that students have not yet learned in class. The biggest challenge for students is determining whether the AI-generated code and its results are verifiably correct.

When students submit these solutions verbatim, they are likely completed with assistance from AI. AI-generated code often is more compact or optimized and can serve as a model for learners when comparing their solutions with AI-generated ones. Instructors can create a learning opportunity by encouraging students to work individually or in small groups to explore the advanced concepts and explain them or add appropriate documentation that demonstrates their understanding.

Future Research

Understanding how students use ChatGPT and other generative AI tools for coding assistance at different stages of their learning process would be useful. Beginners may tend to use AI tools more as a tutor to help them understand coding concepts, while students coding with Python libraries may be more likely to use AI tools as a reference and to provide sample code fragments for further customization. Anecdotal evidence suggests that learners use generative AI tools at the beginning of their coding journeys in a tutoring capacity to master conceptual topics of Python (sequence, selection, repetition, functions, logic) while they use them as more of a reference tool or personal assistant (coding agent) when coding more applied topics such as data structures or interacting with data analytics libraries.

In the latter case, students' use generative AI to save them time by providing syntax for specific data queries or visualization features ("find all of the customers from Massachusetts with orders exceeding $50,000", "place the legend of the chart at the top right", "make the wedges of the pie chart in four different shades of blue") rather than explaining fundamental programming concepts.

A future study might conduct a similar learning scenario twice during the semester, first when students are beginners, and then later when topics are more advanced, to see how and if they still find generative AI helpful.

Conclusions

Students often have a greater sense of understanding and pride in code they wrote themselves because they are more familiar with the logic they used to develop it. They learn from their mistakes in an iterative process to develop functional coding solutions. They can also learn from reading and understanding AI-generated code and code written by their peers to see alternative approaches, how new language features might be used, and different solutions that can inform their future work as coders.

This exercise asked students to develop a Python solution to a programming problem, compare their solution with one generated by AI tools, and evaluate the results from a software quality perspective. The process revealed insights into students' perceptions around using AI for learning, from which educators can leverage generative AI tools in ways that encourage critical thinking and enhance learning outcomes. This study contributes to the body of knowledge that shows that generative AI will play an increasingly important role in computing education.

7. ACKNOWLEDGMENTS

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8. REFERENCES

Aruleba, K., Sanusi, I. T., Obaido, G., & Ogbuokiri, B. (2024). Integrating ChatGPT in a Computer Science Course: Students Perceptions and Suggestions (Version 1). https://doi.org/10.48550/ARXIV.2402.01640

Boehm, B. W., Brown, J. R., & Lipow, M. (1976). Quantitative evaluation of software quality. In *Proceedings of the 2nd International Conference on Software Engineering.*

Chan, C. K. Y., & Hu, W. (2023). Students' voices on generative AI: Perceptions, benefits, and challenges in higher education. *International Journal of Educational Technology in Higher Education*, 20(1), Article 1. https://doi.org/10.1186/s41239-023-00411-8

Choudhuri, R., Liu, D., Steinmacher, I., Gerosa, M., & Sarma, A. (2024). How far are we? The triumphs and trials of generative AI in learning software engineering. In *Proceedings of the IEEE/ACM 46th International Conference on Software Engineering* (pp. 1–13). https://doi.org/10.1145/3597503.3639201

Code.Org. (2024). Learn computer science. Change the world. [Website]. Retrieved August 25, 2024, from https://code.org/

Denny, P., Leinonen, J., Prather, J., Luxton-Reilly, A., Amarouche, T., Becker, B. A., & Reeves, B. N. (2024). Prompt problems: A new programming exercise for the generative AI era. In *Proceedings of the 55th ACM Technical Symposium on Computer Science Education* (Vol. 1, pp. 296–302). https://doi.org/10.1145/3626252.3630909

Feldman, M. Q., & Anderson, C. J. (2024, June). Non-expert programmers in the generative AI future. In *Proceedings of the 3rd Annual Meeting of the Symposium on Human-Computer Interaction for Work* (pp. 1-19). https://doi.org/10.1145/3663384.3663393

Ma, B., Chen, L., & Konomi, S. (2024). Enhancing programming education with ChatGPT: A case study on student perceptions and interactions in a Python course (Version 3). https://doi.org/10.48550/ARXIV.2403.15472

Miguel, J. P., Mauricio, D., & Rodriguez, G. (2014). A Review of Software Quality Models for the Evaluation of Software Products. *International Journal of Software Engineering & Applications*, 5(6), 31–53. https://doi.org/10.5121/ijsea.2014.5603

Shein, E. (2014). Should everybody learn to code? Communications of the ACM, 57(2), 16–18. https://doi.org/10.1145/2557447

Tala, M. L., Müller, C. N., Nastase, I. A., State, O., & Gheorghe, G. (2024). Exploring university students' perceptions of generative artificial intelligence in education. *Amfiteatru Economic,* 26(65), 71-88. https://doi.org/10.24818/EA/2024/65/71

Xing, J. and Jiang, Q. (2024). Factors influencing user experience in AI chat systems – a satisfaction study based on factor analysis and linear regression. Kybernetes. https://doi.org/10.1108/K-10-2023-2237

Zastudil, C., Rogalska, M., Kapp, C., Vaughn, J., & MacNeil, S. (2023). Generative AI in computing education: Perspectives of students and instructors. In *2023 IEEE Frontiers in Education Conference (FIE)* (pp. 1–9). Institute of Electrical and Electronics Engineers (IEEE). https://doi.org/10.1109/FIE58773.2023.10343467

Zhang, Z., Dong, Z., Shi, Y., Price, T., Matsuda, N., & Xu, D. (2024). Students' perceptions and preferences of generative artificial intelligence feedback for programming. In *Proceedings of the AAAI Conference on Artificial Intelligence* (Vol. 38, No. 21, Article 21). https://doi.org/10.1609/aaai.v38i21.30372

Appendix A. BUILD A BIKE Description

In this assignment you are going to write a program to help people interested in buying a bike for commuting to school or work or just for fun and exercise. The program will allow them to configure a bicycle that will meet their needs. Bike buyers may not know what kind of bike is best suited for them so the program will ask them if they bike on paved roads and bike paths; pavement and natural surfaces; and dirt roads and trails. Their selection will then determine a recommendation of the best bike for them.

The program displays the type of bike that is recommended and asks if they want to continue with that selection. If they do, then depending on the type of bike they select, they will be asked for the size of bike, frame material, and handlebars they prefer. The base prices for the models and the additional costs for options are:

Bike Model	Price
Mountain Bike (M)	$1550.00
Hybrid Bike (H)	$1150.00
Road Bike (R)	$1000.00

Frame Size Options	Price
Small (S)	$1000.00
Medium (M)	$1500.00
Large (L)	$2000.00

Frame Material Options	Price
Aluminum (A)	$200.00
Carbon Fiber (C)	$750.00
Steel (S)	$350.00
Aluminum/Carbon Mix (M)	$800.00

Handlebar Options	Price
Flat (F)	$0.00
Riser for Hybrid Bike (R)	$0.00
Riser for Mountain Bike (R)	$50.00
Riser for Road Bike (R)	$75.00
Drop (D)	$50.00

For each model, this chart shows recommended surface types and options for frame and handlebars:

Bike Model	Recommended Surface Type	Frame Materials	Handlebars
Mountain Bike (M)	Dirt roads and trails	Aluminum Carbon Fiber Aluminum/Carbon Fiber Mix	Flat Riser
Hybrid Bike (H)	Pavement and natural surfaces	Aluminum	Riser
Road Bike (R)	Paved roads and bike paths	Aluminum Carbon Fiber Steel	Drop Riser

Requirements

The program starts by asking the user what type of road surface they prefer to bike on; this will determine what kind of bike is best suited for them. Then, regardless of bike type, they will be asked for the size of the frame (this is based on a person's physical size). The next two questions about the frame material and handlebars will be determined by the type of bike that is selected. After all the selections are made, the output with the options selected and the pricing will be displayed in a formatted table. A sample menu might look like this:

```
Build a Bike
What kind of biking do you do?
        A - Dirt road and trails
        B - Pavement and natural surfaces
        C - Paved roads and bike paths
        Enter your choice: A
We recommend a Mountain Bike.
```

Next, display the options available for the recommended bike:

```
Your bike is available in size [S]mall, [M]edium, or [L]arge.
You can choose [A]luminum, [C]arbon Fiber, or Aluminum/Carbon [M]ix.
You can choose [F]lat or [R]iser handlebars.
Enter your choice(s): saf
```

Determine the **bike's product code** by creating a string of the letters shown in parentheses in the tables of bikes and options. For example, the code for a Mountain bike, Small frame, aluminum/carbon Mix, with Flat handlebars is SMF (The type of bike does not need to be repeated). The product code is based on the options shown in the order presented.

Summarize the bicycle configuration and product code with the customer's chosen options in a report. Include the title "**{modelname} {code} Configuration and Price**" where **{modelname}** is the name of the bike model and **{code}** is the code created above. Display results in a formatted table.

```
*****************************************************
     Mountain Bike SAF Configuration and Price:
Type of Bike:     Mountain Bike            $1,550.00
Bike Size:        Small                    $1,000.00
Frame Material:   Aluminum                 $  200.00
Handlebars:       Flat Handlebars          $    0.00
=====================================================
Total Price:                               $2,750.00
```

See the end of the assignment for several sample user interactions.

ADDITIONAL REQUIREMENTS:

- When only one configuration is possible, the program should not display options for which the user has no choice.
- Accept both upper- and lower-case letters for each menu option.
- Format all prices with two decimal places, dollar signs, and commas for values greater than $999.99.
- No input validation needed; you can assume all user input satisfied the requirement.
- Use any knowledge **we covered in class** to finish the program.

YOUR EXTRA CREDIT ASSIGNMENT

Part 1. Write the program yourself using any Python techniques that we learned in class to solve this problem. Do not use any AI tools to assist.

Part 2. Using an AI tool of your choice, provide the problem description for AI to generate a solution in the form of a Python program. Review and run the code generated by AI to verify whether it works, and if it is not correct, determine how to modify your prompt(s) to obtain (hopefully) better results.

Write a report in which you describe:

- The name of the generative AI tool you used.
- Share the link to the conversation you have with AI. Provide the URL or copy and paste your entire conversation as an appendix to your report.

Compare your solution with the one(s) provided by the AI tools you used. Comment on:

- the overall approach that you took compared with that of your generated AI solution. What approach did you take? (how did you represent the data, or navigate through the different choices?) What approach did AI take?
- Did the generated AI code use features of Python that you needed to learn about to understand?
- After reviewing both, which one do you prefer for solving this problem?
- Did you need to refine your prompts to improve the Generative AI solution?

When comparing your solution with the one(s) produced by AI, consider the following aspects regarding the quality of the code. These metrics are based on a seminal paper on computer software quality evaluation (Boehm et al. 1976)[1].

1. **Correctness/Completeness**: Run the AI-generated code on various test cases. Does the code generate correct outputs given different inputs? Does the code provide all the required output?
2. **Efficiency**: Are the data about the application (e.g., pricing information) maintained using efficient data structures? An efficient data structure can reduce the use of control structures (e.g., loop and if statements).
3. **Understandability/ Conciseness**: Is the code easy to read and understand? Is it long and overly complicated? Are comments included and helpful? Is the code so concise that it is hard to understand?
4. **Consistency**: Consistency in code makes it easier to maintain, debug, and for others to collaborate. Is the code consistent in its use of naming variables, indentation, and formatting?
5. **Maintainability/Structuredness**: Code is maintainable if it is modular, does not duplicate steps, and is written in such a way that if business circumstances change, updates to the code to reflect those changes are minimal. For example, does the solution break the problem down into smaller modules or functions? if the business decides to change the prices of their products, would that require a change to many lines of the code?

Submit both your Python code file and your Word doc containing your evaluation of the generated AI code.

RUBRIC

#	Criteria	Points
1	Ask for the user's name and display the user's name in the Welcome prompt	2
2	Compute the calculations from the values provided in the Introduction and as described in the “Calculations” section	10
3	Formatting output with correct number of decimals, separator line of equal signs, new lines.	5
4	Comments and good programming style	1
5	Use of symbolic constants and commented out code	2
	Total	**20**

[1] Boehm, B. W., J. R. Brown, & M. Lipow. (1976). Quantitative evaluation of software quality. *Roceedings of the 2nd International Conference on Software Engineering.*

Sample User Interactions

Sample Run 1

```
Build a Bike
What kind of biking do you do?
        A - Dirt road and trails
        B - Pavement and natural surfaces
        C - Paved roads and bike paths
        Enter your choice: a
We recommend a Mountain Bike.
Your bike is available in size [S]mall, [M]edium, or [L]arge.
You can choose [A]luminum, [C]arbon Fiber, or Aluminum/Carbon [M]ix.
You can choose [F]lat or [R]iser Handlebars.
Enter your choice(s): saf

*****************************************************
     Mountain Bike SMAF Configuration and Price:
Type of Bike:     Mountain Bike             $1,550.00
Bike Size:        Small                     $1,000.00
Frame Material:   Aluminum                  $  200.00
Handlebars:       Flat Handlebars           $    0.00
=====================================================
Total Price:                                $2,750.00
```

Accept both upper- and lowercase inputs.

Sample Run #2

```
Build a Bike
What kind of biking do you do?
        A - Dirt road and trails
        B - Pavement and natural surfaces
        C - Paved roads and bike paths
        Enter your choice: B
We recommend a Hybrid Bike.
Your bike is available in size [S]mall, [M]edium, or [L]arge.
Enter your choice(s): m
*****************************************************
      Hybrid Bike MHAR Configuration and Price:
Type of Bike:     Hybrid Bike               $1,150.00
Bike Size:        Medium                    $1,500.00
Frame Material:   Aluminum                  $  200.00
Handlebars:       Riser Handlebars          $    0.00
=====================================================
Total Price:                                $2,850.00
```

Accept both upper- and lowercase inputs.

Appendix B. Survey

Participant Information

Your Name: ____

In which section of CS 230 are you enrolled?

Which Generative AI tool did you use to generate a solution to this program?

○ ChatGPT ○ Google Bard ○ Grok ○ Copilot ○ Other ___________

Provide a link to your AI chat session if possible.

Analysis

Describe your overall approach to solving this problem, as compared to your AI-generated solution. For example, what Python statements or data structures did you use? How did the AI-generated solution accomplish these tasks?

Did the AI generated solution use features of Python not covered in class that you needed to learn on your own?

Describe the prompts you entered for an AI-generated solution. Did you need to refine them to get the desired results, and if so, how?

Evaluation

Criteria	Your Code	AI Generated Code
Correctness/Completeness Run the code on various test cases. Does the code generate correct outputs given different inputs? Does the code provide all the required output?		
Efficiency Are the data about the application (e.g., pricing information) maintained using efficient data structures? An efficient data structure can reduce the use of control structures (e.g., loop and if statements).		
Understandability/ Conciseness Is the code easy to read and understand? Is it long and overly complicated? Are comments included and helpful? Is the code so concise that it is hard to understand?		
Consistency Consistency in code makes it easier to debug, and for others to collaborate. Is the code consistent in its use of naming variables, indentation, and formatting?		
Maintainability/Structuredness Code is maintainable if it is modular, does not duplicate steps, and is written in such a way that if business circumstances change, updates to the code to reflect those changes are minimal. For example, does the solution break the problem down into smaller modules or functions? If the business decides to change the prices of their products, would that require a change to many lines of the code?		

In this section we ask you to review your solution and the solution generated by AI based on several considerations often used when evaluating software.

After reviewing both solutions, which do you prefer and why?

Opinion

To what extent do you disagree or agree with these statements?
(Scale: Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree)

Student Experience

1. I enjoyed using AI tools to generate a solution for this assignment
2. I found the AI-generated solutions to be clear, concise, and relevant to the assignment
3. I trust the solutions AI-generated to be correct and accurate

Impact of Generative AI on Learning

4. I learned new Python programming skills or techniques by examining the AI-generated solutions
5. I would recommend using AI as a learning tool.
6. Reviewing code generated by AI tools increased my confidence in writing code myself
7. Using generative AI helped me learn how to read and interpret Python code as a solution for this assignment

Appendix C. Variable Coding

Original Value	Dummy
Questions 1-7 and 15	
Strongly disagree	1
Strongly agree	5
Questions 7 8 9 10	
When students inferred their code is better than AI generated code (regarding to the question aspect)	2
When students inferred their code is satisfied and did not mention AI generated code (regarding to the question aspect)	1
When students inferred their code is similar to AI generated code (regarding to the question aspect)	0.75
When students inferred their code is worse than AI generated code, but still acceptable (regarding to the question aspect)	0.5
When students inferred their code is not good at all (regarding to the question aspect)	0
Questions 16 19 20 21	
When students inferred AI generated code is better than their code (regarding to the question aspect)	2
When students inferred AI generated code is satisfied and did not mention their own code (regarding to the question aspect)	1
When students inferred AI generated code is similar to their code (regarding to the question aspect)	0.75
When students inferred AI generated code is worse than their code, but still acceptable (regarding to the question aspect)	0.5
When students inferred AI generated code is not good at all (regarding to the question aspect)	0
For Question 13	
Prefer Student Code	0
Prefer AI code	1
Mix/Both	0.75
Gender	
M	1
F	0
Question 11	

Students mentioned AI generated code is more clean/concise/shorter	1, 0 if not mentioned
Students mentioned AI generated code is worse	1, 0 if not mentioned
Students mentioned AI generated code used more functions	1, 0 if not mentioned
Students mentioned AI generated code used more dictionaries	1, 0 if not mentioned
Students mentioned AI generated code used more control structures	1, 0 if not mentioned
Students mentioned AI generated code used other python structures	1, 0 if not mentioned
Students mentioned their code is more clean/concise/shorter	1, 0 if not mentioned
Students mentioned their code is worse	1, 0 if not mentioned
Students mentioned their code used more functions	1, 0 if not mentioned
Students mentioned their code used more dictionaries	1, 0 if not mentioned
Students mentioned their code used more control structures	1, 0 if not mentioned
Students mentioned their code used other python structures	1, 0 if not mentioned
Question 12	
Yes	1
No	0
No but more complex or not the way student use	0.5
Question 14	
Student mentioned putting assignment in	1, 0 if not mentioned
Student mentioned needing multiple inputs	1, 0 if not mentioned
Student mentioned they asked AI to fix code	1, 0 if not mentioned
Student mentioned they were Interested in AI results	1, 0 if not mentioned
Student mentioned they got the correct output	1, 0 if not mentioned
Student mentioned they cannot get the correct output	1, 0 if not mentioned
Student mentioned they were satisfied with AI code	1, 0 if not mentioned
Student mentioned they were not satisfied with AI code	1, 0 if not mentioned

Appendix D. Sample Student and AI-Generated Solutions

This appendix presents a sample solution and analysis from one student. The student began by copying and pasting much of the assignment description into ChatGPT, which generated code using functions, lists, and dictionaries, topics yet not covered when the assignment was given originally. (These structures were covered later in the course and were permitted to use in this assignment.) The student engaged in a dialog with ChatGPT, reviewing the code generated and responses at each step, and refining prompts until it generated the desired results. The complete dialog is available at https://chatgpt.com/share/aee41dce-3286-4a87-8373-76d8f086f703 .

The student's prompts shown below are copied verbatim from the ChatGPT dialog; only spelling errors were corrected.

- For formatting the what type of biking do you do? options should each be on their own line. you should display the available options and then get the user to input a 3 letter value for the selection. The format of the final cost table should have type of bike on the left, option picked in the middle and price on the right and all the options in the columns should be lined up

- provide all of the bike selection options before asking the user to input three letters for their selection. The total table should also line up

- this is how you should display the additional options for the bikes: Next, display the options available for the recommended bike: Your bike is available in size [S]mall, [M]edium, or [L]arge. You can choose [A]luminum, [C]arbon Fiber, or Aluminum/Carbon [M]ix. You can choose [F]lat or [R]iser handlebars. Enter your choice(s): saf

- ask one time for the user to input information and then split the three letter value the user gives you to determine the bike options

- *** Mountain Bike SAF Configuration and Price: Type of Bike: Mountain Bike $1,550.00 Bike Size: Small $1,000.00 Frame Material: Aluminum $ 200.00 Handlebars: Flat Handlebars $ 0.00 == Total Price: $2,750.00 put the final total table in the above format. Move the prices to be all the way on the right with their last value in line with the above and below = signs. Also put the options chosen by the user in the middle of the table

- write out the full code

- dont give the short versions of the options in the total table, write out the users selected options out in full

When the student ran AI's code this time, it had a runtime error, which they pasted in for help:

- Traceback (most recent call last):
  File "C:\Users\Student\CS 230\Extra Credit GhatGPT.py", line 86, in <module>
  main()
  File "C:\Users\ Student \CS 230\Extra Credit GhatGPT.py", line 39, in main
  display_configuration(bike_type, frame_size, frame_material, handlebars, product_code)
  File "C:\Users\ Student \CS 230\Extra Credit GhatGPT.py", line 69, in display_configuration
  + frame_material_prices[frame_material]
  ~~~~~~~~~~~~~~~~~~~~~~~~^^^^^^^^^^^^^^^^
  KeyError: 'A'
  ~~~~~~~~~~~~~~~~~~~~~~~~

The student appeared to get frustrated:

- write out the code in full from now on
- line 73, in display_configuration + handlebar_prices[handlebars] ~~~~~~~~~~~~~~~~^^^^^^^^^^^^ KeyError: 'R'
- write out the code in full again
- the bike size should be Small and not just s
- REWRITE THE WHOLE CODE
- please please please just take into account everything ive said before when writing the code out
- dont have the options on different lines except for the first ABC part
- have it in this layout What kind of biking do you do? A - Dirt road and trails B - Pavement and natural surfaces C - Paved roads and bike paths Enter your choice: A We recommend a Mountain Bike
- FORMAT LIKE THIS: Your bike is available in size [S]mall, [M]edium, or [L]arge. You can choose [A]luminum, [C]arbon Fiber, or Aluminum/Carbon [M]ix. You can choose [F]lat or [R]iser handlebars. Enter your choice(s):

Finally, the student either gave up or was happy with the AI-generated results.

The student wrote this report after analyzing their code and comparing it with the AI-generated results.

The Extra Credit was completed using ChatGPT 3.5

1. I completed the online form and submitted my responses. I did not unfortunately copy past most of my responses I filled out, but I did copy the metrics and how well ChatGPT did in each of them.
2. Correctness/Completeness: The AI was able to get the correct output after a lot of prompting it. It has the correct way of asking for the user inputs and successfully calculates the ending totals. However even after a lot of prompting it was unable to successfully format the totals column, and line the columns up. The AI version does successfully run all the options.
3. Efficiency: The AI version of the code does a good job with the functions and putting different options for the types of bikes into functions. However, there are some things in the code that the AI should use functions for like pricing that it doesn’t, the AI also has a significantly longer main function than it should ideally have since the main function is 39 lines long.
4. Understandability/Conciseness: The code by the AI is understandable and concise with the code being about the same length as my own 102 vs 105, but the AI has significantly more empty lines and comments, so it is probably about only 70 lines of actual code
5. Consistency: The AI was very consistent with its variable naming, indentations, and formatting. Although it could not figure out how to correctly format the final table even after significant prompting.
6. Maintainability/Structuredness: The AI code is somewhat maintainable and modular. The AI does use dictionaries, so it makes it easier to change prices. However, the AI uses a very large main function to do a lot of the heavy lifting instead of using functions which makes it less maintainable.

The student’s solution and the AI-generated solution follow.

Student Solution	AI-Generated Solution

<pre>"""GENAI Program Extra Credit. Build a Bike
Program by Student Name"""
 	
Frame = [{"A": ["Aluminum", 200]}, {"C":
["Carbon Fiber", 750]}, {"M":
["Aluminium/Carbon Mix", 800]},
         {"S": ["Steel", 350]}] # Frame
options
Handles = [{"F": ["Flat", 0]}, {"R": ["Riser
for Mountain Bike", 50]}, {"R": ["Riser for
Road Bike", 75]},
           {"R": ["Riser for Hybrid Bike",
50]}, {"D": ["Drop", 50]}] # Handle options
 	
def intro(): # Recommend bike type based on
type of riding the user does
    print("Build a Bike")
    print("What kind of biking do you do?")
    print("A - Dirt road and trails \n"
          "B - Pavement and natural surfaces
\n"
          "C - Paved roads and bike paths
\n")
    bike_type = input("Enter your choice:
").upper()
    if bike_type == "A":
        print("We recommend a Mountain
Bike")
    elif bike_type == "B":
        print("we recommend a Hybrid Bike")
    elif bike_type == "C":
        print("We recommend a Road Bike")
    return bike_type
 	
def selection(bike_type):
    if bike_type == "A": # Gives options
based on the user selecting Mountain Bike
        print("Your bike is available in
size [S]mall, [M]edium, or [L]arge. \n"
          "You can choose [A]luminum,
[C]arbon Fiber, or Aluminum/Carbon [M]ix.
\n"
          "You can choose [F]lat or [R]iser
handlebars. \n")
        choices = input("Enter your
choice(s): ").upper()
    elif bike_type == "B": # Gives options
based on the user selecting Hybrid Bike
        print("Your bike is available in
size [S]mall, [M]edium, or [L]arge. \n"
              "You can choose [A]luminum \n"
              "You can choose [R]iser
handlebars. \n")
        choices = input("Enter your
choice(s): ").upper()</pre>
	<pre>def main():
	    print("Build a Bike")
	
	    # Display options for bike type
	    print("\nWhat kind of biking do you do?
	\n"
	          " A - Dirt road and trails \n"
	          " B - Pavement and natural
	surfaces \n"
	          " C - Paved roads and bike
	paths")
	    surface_choice = input("Enter your
	choice: ").lower()
	
	    # Determine the recommended bike type
	based on the user's choice
	    bike_type = get_bike_type(surface_choice)
	    print(f"We recommend a {bike_type}
	Bike.")
	
	    # Display options available for the
	recommended bike
	    frame_sizes, frame_materials, handlebars
	= get_bike_options(bike_type)
	
	    print(f"\nYour bike is available in size
	[{', '.join(frame_sizes)}].")
	    print(f"You can choose [{',
	'.join(frame_materials)}].")
	    print(f"You can choose [{',
	'.join(handlebars)}].")
	
	    # Get user input for size, frame
	material, and handlebars
	    choices = input("\nEnter your choice(s):
	").upper()
	
	    # Validate the length of the user input
	    if len(choices) != 3:
	        print("Invalid input. Please enter
	exactly three letters.")
	        return
	
	    # Split the three-letter value to
	determine size, frame material, and
	handlebars
	    frame_size =
	get_frame_size_full(choices[0])
	    frame_material = choices[1]
	    handlebars = choices[2]
	
	    # Generate product code
	    product_code = frame_size[0] +
	frame_material[0] + handlebars[0]
	
	    # Display the bicycle configuration and
	price</pre>

<table>
<tr><th>Student Solution</th><th>AI-Generated Solution</th></tr>
<tr><td>
<pre>
    else:
        print("Your bike is available in
size [S]mall, [M]edium, or [L]arge. \n"
              "You can choose [A]luminum,
[C]arbon Fiber, or Steel (S) \n"
              "You can choose [D]rop or
[R]iser handlebars. \n")
        choices = input("Enter your
choice(s): ").upper()
    return choices

def price_calculation(bike_type, bike):
    total_price = 0
    if bike_type == "A": # Determines price
if type of bike is mountain bike
        total_price += 1550
        bike_name = "Mountain Bike"
        bike_kind = 1550
    elif bike_type == "B": # price for
hybrid bike
        total_price += 1150
        bike_name = "Hybrid Bike"
        bike_kind = 1150
    else:
        total_price += 1000
        bike_name = "Road Bike" # price for
road bike
        bike_kind = 1000
    if bike[0] == "S": # price for small
size bike
        total_price += 1000
        size = "Small"
        size_price = 1000
    elif bike[0] == "M":
        total_price += 1500
        size = "Medium"
        size_price = 1500
    else:
        total_price += 2000
        size = "Large"
        size_price = 2000
    frame_price = 0
    handle_price = 0
    frame_type = 0
    handle_type = 0
    for i in Frame: # loop to determine
which cost of selected bike frame
        for key, value in i.items():
            if key == bike[1]:
                frame_price = int(value[1])
# converts dictionary value into integer
                frame_type = value[0]
    for i in Handles: # loop to determine
cost of handle bar type
        for key, value in i.items():
            if key == bike[2]:
                handle_price = int(value[1])
</pre>
</td><td>
<pre>
    display_configuration(bike_type,
frame_size, frame_material, handlebars,
product_code)

def get_bike_type(surface_choice):
    if surface_choice == 'a':
        return "Mountain"
    elif surface_choice == 'b':
        return "Hybrid"
    elif surface_choice == 'c':
        return "Road"

def get_bike_options(bike_type):
    if bike_type == "Mountain":
        return ['Small (S)', 'Medium (M)',
'Large (L)'], ['Aluminum (A)', 'Carbon Fiber
(C)', 'Aluminum/Carbon Mix (M)'], ['Flat
(F)', 'Riser (R)']
    elif bike_type == "Hybrid":
        return ['Small (S)', 'Medium (M)',
'Large (L)'], ['Aluminum (A)'], ['Riser (R)']
    elif bike_type == "Road":
        return ['Small (S)', 'Medium (M)',
'Large (L)'], ['Aluminum (A)', 'Carbon Fiber
(C)', 'Steel (S)'], ['Drop (D)', 'Riser (R)']

def display_configuration(bike_type,
frame_size, frame_material, handlebars,
product_code):
    # Define base prices
    bike_prices = {'Mountain': 1550.00,
'Hybrid': 1150.00, 'Road': 1000.00}
    frame_material_prices = {'A': 200.00,
'C': 750.00, 'S': 350.00, 'M': 800.00}
    handlebar_prices = {'F': 0.00, 'R':
50.00, 'D': 50.00}

    # Convert frame_material and handlebars
to the full names
    frame_material_full =
get_frame_material_full(frame_material)
    handlebars_full =
get_handlebars_full(handlebars)

    # Calculate total price
    total_price = (
        bike_prices[bike_type]
        +
frame_material_prices[frame_material]
        + handlebar_prices[handlebars]
)

    # Display the configuration and price in
the specified format
    print("\n" + "=" * 54)
</pre>
</td></tr>
</table>

<table>
<tr><th>Student Solution</th><th>AI-Generated Solution</th></tr>
<tr><td>

```
                handle_type = value[0]
    total_price += frame_price
    total_price += handle_price
    print("*" * 55)  # prints table of
prices
    print("Mountain Bike SAF Configuration
and Price:".center(55))
    print(f"{'Type of Bike':<15}
{bike_name:<31} ${bike_kind:>9.2f}")
    print(f"{'Bike Size':<15} {size:<31}
${size_price:>9.2f}")
    print(f"{'Frame Material':<15}
{frame_type:<31} ${frame_price:>9.2f}")
    print(f"{'Handle Bars':<15}
{handle_type:<31} ${handle_price:>9.2f}")
    print("=" * 55)
    print(f"{'Total Price':<47}
${total_price:>9.2f}")


def main():
    bike_type = intro()
    choices = selection(bike_type)
    price_calculation(bike_type, choices)


main()
```

</td><td>

```
    print(f"{bike_type} Bike {product_code}
Configuration and Price:")
    print(f"Type of Bike: {bike_type} Bike{'
' * (11 -
len(bike_type))}${bike_prices[bike_type]:>13,
.2f}")
    print(f"Bike Size:
{get_frame_size_full(frame_size)}{' ' * (14 -
len(get_frame_size_full(frame_size)))}${frame
_material_prices[frame_material]:>13,.2f}")
    print(f"Frame Material:
{frame_material_full}{' ' * (14 -
len(frame_material_full))}${frame_material_pr
ices[frame_material]:>13,.2f}")
    print(f"Handlebars: {handlebars_full}
Handlebars{' ' * (13 -
len(handlebars_full))}${handlebar_prices[hand
lebars]:>13,.2f}")
    print("=" * 54)
    print(f"Total Price: {' ' *
41}${total_price:,.2f}")
    print("=" * 54)


def get_frame_size_full(frame_size):
    frame_size_options = {'S': 'Small', 'M':
'Medium', 'L': 'Large'}
    return frame_size_options.get(frame_size,
frame_size)


def get_frame_material_full(frame_material):
    frame_material_options = {'A':
'Aluminum', 'C': 'Carbon Fiber', 'S':
'Steel', 'M': 'Aluminum/Carbon Mix'}
    return
frame_material_options.get(frame_material,
frame_material)


def get_handlebars_full(handlebars):
    handlebars_options = {'F': 'Flat', 'R':
'Riser', 'D': 'Drop'}
    return handlebars_options.get(handlebars,
handlebars)


if __name__ == "__main__":
    main()
```

</td></tr>
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The Virtual Stage: Virtual Reality Integration in Effective Speaking Courses

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Abstract

This research examines the implementation of virtual reality into an effective speaking course at a small business college in New England. The researchers detail how they piloted the use of MetaQuest 2 headsets to students for round-the-clock availability of public speaking software in an Effective Speaking course. Students were administered a pre-and post-survey to gauge their feelings about public speaking before and after the virtual reality intervention. The results indicate statistically significant improvements in speech confidence and anxiety level reduction. In addition, student and instructor attitudes toward VR exposure in the classroom are overwhelmingly positive.

Keywords: virtual reality, metaverse, public speaking, education, experiential learning

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The Virtual Stage: Virtual Reality Integration in Effective Speaking Courses

Adam Patterson, Cathy Temple, Nikki Anderson, Chris Rogalski and Kevin Mentzer

1. INTRODUCTION

Virtual Reality (VR) is a technology that resides in the Reality-Virtuality Continuum (Milgram et al., 1995). On one end is the real environment (Reality); this is the non-digital world we live in. On the other end, there is a fully digital environment (VR) in which the entire domain is digitally constructed. Along the continuum, there is also Augmented Reality (AR), where virtual objects are overlaid in a real-world environment, and augmented virtuality (AV), where real objects are projected into a virtual world.

The COVID-19 pandemic highlighted the need for non-real environment solutions with an emphasis on remote work and remote learning capabilities. The World Economic Forum (2022) went as far as stating that VR will reshape the future of education, highlighting that while online educational tools were critical to overcoming the challenges posed by the pandemic, they were limited in that they lacked experiential learning. This is where innovative technologies such as AR and VR come into play. Academic institutions must understand how VR may fit into the curriculum.

VR uses computer modeling and simulations to allow individuals to be fully immersed in an artificial 3D environment (Abich et al., 2021). There are three types of VR systems: non-immersive, semi-immersive, and total immersive (Moro et al., 2016). Non-immersive consists of environments visualized in conventional technology, such as monitors and screens. Semi-immersive comprises a combination of real and virtual environments for simultaneous interaction. Total immersive includes three-dimensional simulated environments using head-mounted displays. The latter two levels are considered the metaverse (Hwang & Chien, 2022). The objective of VR is to make the user feel like they are inside the computer-generated system (Saeed et al., 2017).

Although VR technology has been available since the 1960s, recent developments in hardware and quality have allowed mass adoption in the gaming and entertainment industries (Wohlgenannt et al., 2020). Given these advancements, it has been stated that the metaverse is the future of the internet (Bhattacharya et al., 2023; Cui et al., 2022; Ramesh et al., 2022; Ritterbusch & Teichmann, 2023).

The high levels of immersion offered in VR systems can potentially enhance conceptual understanding in academic applications (Holly et al., 2021). Student activities with increased engagement are found to help overall learning (Carini et al., 2006; Patterson et al., 2023). However, a comprehensive literature review of VR applications in academia found that the technology is not widely used despite enhancing student learning outcomes (Alfarsi, 2021).

More specifically, VR has excellent potential for impact regarding increased engagement in public speaking courses. According to Zhou et al. (2021), approximately 77% of people fear public speaking. VR provides a unique solution to this issue, as individuals can experience a learning point of view during intimidating situations while staying sheltered (Halarnkar et al., 2012). A meta-analysis of VR on public speaking indicates an overall statistically significant effect of anxiety reduction (Lim et al., 2023).

Although the benefits of metaverse adoption in academia and public speaking are plentiful, VR usage has consequences. For example, research shows that cyber-sickness is prevalent among VR application users (Martirosov et al., 2022). Cost and user experience are also problematic in hindering widespread adoption (Kavanagh et al., 2017).

According to a systematic review of 61 papers examining VR in education, user perception and impact have not been explored in detail (Noah & Das, 2021). This study fills a research need to understand student and instructor perspectives while recognizing the impact of VR in academic settings.

This paper details the deployment, application, and student/instructor experience of VR headsets during a pilot in an effective speaking course at a small business college in New England. Each student is required to take an effective speaking course to graduate. Throughout the course, students are required to perform weekly presentations, group presentations, engage in workshops, and participate in an elevator pitch competition.

This exploratory study was guided by the following questions:

- RQ1: What are students' attitudes toward implementing VR technology in the pilot course?
- RQ2: How might increased immersion resulting from VR influence student learning outcomes in public speaking?
- RQ3: How does VR influence engagement within an effective speaking course?
- RQ4: In what ways might negative side effects, such as cyber-sickness and headaches, impact the adoption of VR in academic settings?

This study contributes directly to previously limited knowledge surrounding VR's impacts on introductory-level communication courses. The researchers present both statistical results of exposure to the technology and detail student attitudes toward usage. Establishing information about VR technology provides insight to instructors about potential adoption in courses.

2. LITERATURE REVIEW

According to Hwang and Chien (2022), research on metaverse applications in academia is sparse despite the tremendous learning potential that recent technological advances have brought. Much literature denoting educational applications of the metaverse focuses on learning second languages (Alwafi et al., 2022; Gruber & Kaplan-Rakowski, 2020; Muthmainnah et al., 2023; Netta et al., 2020; Wang et al., 2023; Yuan et al., 2023).

Investigations in non-academic settings revolving around the impact of VR on public speaking are well established. Research by Reeves et al. (2021), utilizing a randomized control trial, found that VR exposure reduced public speaking anxiety and fear of negative evaluation. According to Anderson et al. (2013), a randomized control trial reported VR interventions exhibited significant improvement in all measures of public speaking for individuals diagnosed with social anxiety disorder.

Anderson et al. (2013) and Lim et al. (2023) provide robust evidence supporting the effectiveness of VR exposure therapy in reducing anxiety levels, noting significant improvements in users' confidence and performance. Similarly, Frisby et al. (2020) and Kryston et al. (2021) focus on integrating VR into public speaking courses, demonstrating how it can enhance students' self-efficacy and engagement.

In contradiction to these results, implementing VR headsets embedded with public speaking training software in a college-level introductory public speaking course found that the technology did not reduce public speaking anxiety (Kryston et al., 2021). It is essential to investigate the results of VR in higher education as much research indicates a fear of public speaking among students (Grieve et al., 2021).

Additionally, students may be unique adopters of the technology. According to Frydenberg et al. (2024), VR exposure at a business school showcased varying attitudes among students, as some showed interest while others struggled to connect their prior gaming experience with VR to business applications. Further supporting this argument is a study that deployed VR headsets in an introductory communication course, indicating that the technology both hindered and enhanced students' abilities to practice communication skills (Frisby et al., 2020).

Abich et al. (2021) highlight the overall effectiveness of VR in training environments, emphasizing the ability to create immersive and interactive scenarios that promote skill acquisition. Similarly, Alfarsi (2021) explores VR's applications in education, noting its potential to enhance engagement and learning outcomes across various domains. These studies collectively underscore VR's transformative potential in education and beyond, yet they also highlight gaps in evaluating long-term retention and the scalability of VR-based interventions.

This study contributes directly to previously limited knowledge surrounding VR's impacts on introductory-level communication courses. The researchers present both statistical results of exposure to the technology and detail student attitudes toward usage. Establishing information about VR technology provides insight to instructors about potential adoption in courses.

Innovative technology does not necessarily improve students' public speaking skills, as Clark and Jones (2001) found no significant differences in students' public speaking abilities between face-to-face courses and online offerings. In addition, a common belief is that current college students are tech-savvy, but this cannot be assumed (Mentzer et al., 2024). The findings in this research may also provide insights into the technological adoption, of VR, by current students.

3. METHODOLOGY

Meta's Meta Quest 2 devices were set up in the Meta for Business application, a mobile device management (MDM) tool for controlling features and deploying software within headsets. The researchers purposely decided to put no device restrictions on the accounts. Thus, some students may have chosen to use their headsets for entertainment.

The first half of the semester was spent configuring the headsets, training the deployment team, and working with IT so they were prepared to support the rollout. For the last six weeks of the semester, students enrolled in the pilot course *COMM-257 Effective Speaking* received Meta Quest 2 headsets to take home. Before receiving the headsets, students were asked to consent to participate in research and complete a Qualtrics survey (note that students could opt out of the survey and still participate in the pilot program). The questions asked are detailed in Appendix A.

Each headset was equipped with the VirtualSpeech application in addition to all the default applications that came with the headset. VirtualSpeech is VR professional development training software that offers learning paths such as compelling storytelling, sales pitch and closing, salary negotiations, job interview preparation, business networking, and elevator pitches. Learning paths are a curated collection of courses providing students with a straight route to professional development and career goals.

On the day the headsets were distributed, students were given a hands-on lesson on setting up their accounts and logging into VirtualSpeech. Students were encouraged to complete the public speaking mastery learning path for skill enhancement. All tasks in VirtualSpeech were voluntary and not included in the calculation of final grades.

Analytics included for administrators of VirtualSpeech software include total VR time, number of sessions per student, and completed learning paths or courses. The data also details the number of speeches each student finished and their overall score.

The application also provides an automated analysis of each speech. Students are graded based on eye contact score, words per minute, voice volume, filler words, and listenability. In addition to students receiving instant feedback on areas to improve through their scoring, instructors have the option to easily embed performance analytics as part of course evaluation.

A significant benefit of each student having their headset for six weeks is the continuous availability of a virtual avatar audience for practicing speeches. The tool allows students to gain instant assessment at any time of the day or night.

Upon returning the headsets to class during the last week of the semester, students were asked to complete a post-survey. This post-survey included Likert scale inquiries to match the pre-survey and open-ended responses to understand their attitudes and feelings toward VR.

Research questions are addressed from the pre- and post-survey results of students exposed to VR within the effective speaking course (n=15). It is to be noted that many students downloaded applications with virtual meeting spaces, as evidenced by (a) the library of apps and (b) interactions with Meta users they met and engaged with online. Although unexplored, these other applications may have provided another outlet for students to practice their public speaking. These platforms could have allowed students to simulate real-world scenarios, engage with diverse audiences, and gain confidence in their communication skills.

Students were asked six questions, all with a 7-point Likert response scale, to help researchers quantify the impact of VR on their public speaking skills and course experience. Questions included their feelings of anxiety, comfort level, and confidence before giving a speech. Satisfaction with past speeches and student perspectives on the importance of public speaking were also included. The last question gauged student enjoyment in the effective communication course.

Mean responses from the pre-and post-survey are statistically analyzed to understand potential significant outcomes better. Although the responses appear normally distributed to a certain degree (see Figure 1 in Appendix), and only the anxiety variable results in rejecting the Shapiro-Wilk normality test, a Wilcoxon signed-rank test is performed in place of the traditional paired t-test.

The sample size used in this analysis is too small to approximate a normal distribution, which is an assumption of the commonly used t-test. Since violating this assumption can lead to unreliable results, the Wilcoxon signed rank test was chosen instead (Taheri & Hesamian, 2013). The Wilcoxon test is a non-parametric alternative to the t-test that offers a more stable result with low observations (< 30) or non-normal distributions (I.C.A & Ebuh, 2012).

At the end of the post-survey, open-ended questions were asked to evaluate attitudes toward the pilot program qualitatively. Given the small sample size, the answers were visually analyzed to provide insights into student perceptions of the pilot program.

4. RESULTS

Student Feedback

The sample's average age was 18 years old, with every student a freshman class rank. Sixty-seven percent of respondents were female. Eighty percent of students were enrolled to pursue a Bachelor of Arts degree compared to the 20 percent enrolled to obtain a Bachelor of Science in Business Administration.

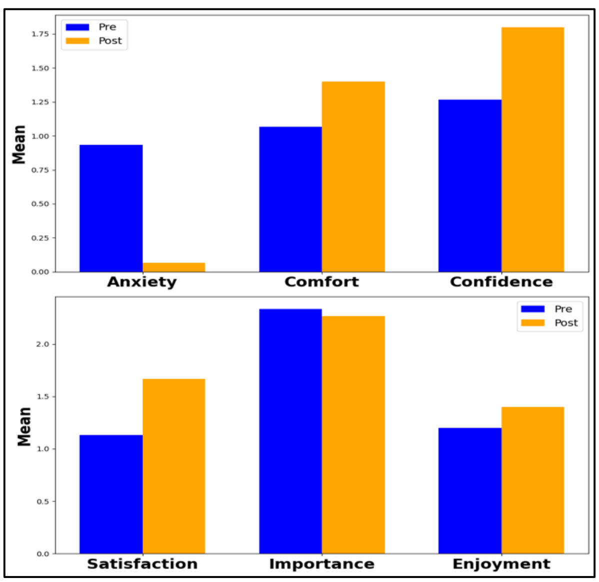

Figure 1: Pre- and Post-Survey Mean Values

The mean responses, showcased in Figure 1, indicate a sharp drop in feelings of anxiety before public speaking. Comfort, confidence, and satisfaction increased noticeably, reflecting a positive shift in students' self-perception and readiness to engage in public speaking tasks. Course enjoyment also showed a marginal improvement, suggesting that students found the learning experience more rewarding as they progressed. Interestingly, the perceived importance of public speaking experienced a slight decline from pre- to post-public speaking, possibly indicating a reevaluation of priorities or a sense of reduced pressure after gaining VR experience.

Table 1 exhibits the Wilcoxon results, providing a statistical validation of these changes. These findings highlight the program's effectiveness in addressing anxiety and enhancing key emotional factors associated with public speaking, even if some dimensions showed more subtle shifts.

Question	Pre-mean	Post-mean	Wilcoxon P-value
Anxiety	0.93	0.07	0.025852*
Comfort	1.07	1.40	0.327489
Confidence	1.27	1.80	0.033471*
Satisfaction	1.13	1.67	0.103483
Importance	2.33	2.27	0.705457
Enjoyment	1.20	1.40	0.453695

Table 1: Wilcoxon Test Results

In answering RQ2, the findings indicate that students experienced a statistically significant increase in public speaking confidence and a statistically significant decrease in anxiety before giving a speech. The Wilcoxon signed-rank test reported no significant difference in student enjoyment of the course. The desired course learning outcomes of increased confidence and decreased speech anxiety may be, at least partially, attributed to the VR intervention. According to Akbari and Sadhibzada (2020), increased student confidence reduces student anxiety and positively benefits their learning process. Research indicates that student anxiety plays a crucial role in learning outcomes, and alleviating learner anxiety significantly enhances learning outcomes (Cao & Yu, 2023).

Impacting both student anxiety and confidence provides VR with potentially powerful outcomes. Communication departments are seeking best practices for reducing public speaking anxiety, as this topic is a standard goal of introductory courses (Hunter et al., 2014). Additionally, increased public speaking confidence is often a significant advantage for undergraduates completing a basic communication course (Finn et al., 2009).

To answer RQ1, the quotes below were obtained as part of the open-ended responses. Visual analysis indicates an overwhelmingly positive experience.

- “I found it to be helpful to get my words straight for my speech.”
- “It helped me have a mock audience and be able to say my speech out loud before I had to present.”
- “Virtual speech helped me improve my public speaking confidence.”
- “Felt like it helped me feel more comfortable in front of real people.”
- “It was fun and helped me a lot.”
- “It helped me be better as I was able to feel like I was presenting in front of people.”
- “I didn't use it. I didn't find any huge use in practicing with a headset on.”
- “Improved my public speaking.”
- “It helped in many ways and gave me many different outlooks on different speeches.”
- “It has helped me.”
- “Great impact on my public speech.”

Next, students were asked to describe their experience using the VR headset. The following are quotes obtained directly from the post-survey:

- “It was fairly enjoyable.”
- “It was relatively easy to use.”
- “It was a fun, good experience.”
- “I really enjoyed using the virtual reality headsets.”
- “I loved it!”
- “It was super useful and fun.”
- “It was fun and easy to use.”
- “It was a cool experience.”
- “It was fun for the games besides the virtual speech but again I lost interest after one day.”
- “It was a lot of fun.”
- “It helped me to practice for the real speech in class.”
- “Sometimes got loose beside that totally fine.”
- “It was a good, fun experience.”

In addition to the quotes, most of the feedback reported to the pilot's professor during class meetings was about the fun factor instead of the effectiveness of the learning modules. This is not surprising, as this was the program's first rollout, and it serves as a basis for moving forward regarding student directives and course expectations.

With respect to RQ3, research indicates that students who are more satisfied with their academic experience show a higher degree of engagement and achieve better grades (Roebken, 2007). Course satisfaction and course enjoyment scores both increased from the pre- to the post. Although not statistically significant, these results may provide insights into student engagement throughout the course and their perception of VR applications in the classroom.

Regarding RQ4, the survey asked respondents if they experienced headaches or dizziness while using the VR headset and, if so, how they dealt with it. Seven students reported getting headaches while using the VR system. One student reported that the headaches would occur after an hour and a half of continuous usage. Five students said they removed the headset and stopped using VR whenever the headaches occurred. No students reported that negative side effects were a reason to abstain from the headsets. It is important, however, to recognize that students cannot perform academic activities for extended times without getting cyber-sickness from the headsets that they were given.

According to the software's analytics, the average time spent on VirtualSpeech throughout the pilot was 4.5 hours per student, while time spent on entertainment and other applications was not tracked. In addition to using the headset for practice with public speaking, students were asked how else they used VR. 12 students responded that they utilized the technology for YouTube, Netflix, or gaming.
The last survey question asked students if they had suggestions for improving this experience for future offerings. Most responses included “None” or “No,” while one student asked for the requirement of more VirtualSpeech lessons and another opined that more outside applications, other than VirtualSpeech, should be incorporated.

Instructor Feedback
The course professor was from the Communications department and had little to no experience with VR but was enthusiastic about its use. According to the professor, it was easy to incorporate the headsets into the course for several reasons. First, VR is playful, and young students find it easier to learn through engaging gamification methods. Second, the technology is unique and compelling for all ages. Third, using VR technology in the context of learning gives students many choices and is empowering as their use and availability of choices negates top-

down learning styles present in traditional classroom pedagogical settings.

According to the instructor, there are a few areas for improvement. Items to improve for future semesters include more directives regarding class expectations for their use and closely monitoring the data generated to increase the usage of VR headsets for coursework over entertainment purposes in real-time. VR headsets may still be used for entertainment purposes with increased course directives.

Per the instructor, VR headsets can be effective in helping students feel more comfortable talking in front of people since individuals can create a virtual classroom of avatars to replicate how that might feel in person. As a result, students can create and act through scenarios that explore personal feelings that are may be hard to reproduce in their day-to-day lives. Surprisingly, this VR classroom can also help create a more vital consciousness in students who spend much time mindlessly scrolling their phones.

Student feedback in previous semesters with traditional learning indicates that when a student speaker looks out at a group of peers primarily on their phones, they feel their presentations diminish. It is “hard to concentrate” on the content they have created and practiced. In this scenario, everybody loses as the student speaker’s scores go down, the presentation may not be as vibrant as it originally was, and they feel far less confident as they perceive that nobody is listening to them. The avatars that exist now are listening, non-phone-holding, and engaged in the speech.

The observation was made that some students associated the VR headsets with a game-type feeling. Gamification bridges the gap between traditional education and students' digital familiarity (Lampropoulos & Kinshuk, 2024). The combination of gamification and VR helped to create an engaging and interactive learning environment that enhanced student motivation and retention.

Some students felt as though they were part of an interactive story, alleviating the anxiety public speaking can often bring (Grieve et al., 2021). Moreover, gamification within VR encouraged self-reflection. This self-reflective aspect cultivates a growth mindset, empowering students to take ownership of their progress.

To improve the teaching and integration of VR headsets more seamlessly into an effective speaking course, it is beneficial to focus on enhancing familiarity with VR tools and the strategic incorporation of these resources into the curriculum. This could involve participating in professional development workshops or training sessions to deepen understanding of VR technology and its applications in communication skills training.

By collaborating with IT and colleagues more experienced in VR integration, instructors could be better equipped to troubleshoot potential challenges and develop best practices. Additionally, gathering more student feedback on their VR experiences would help refine the approach, defining that the technology is not just a novel tool but a meaningful enhancement to the student learning experience.

5. DISCUSSION AND CONCLUSION

Our results corroborate previous research indicating that VR applications have the potential to reduce public speaking anxiety and promote increased communicative confidence (Reeves et al., 2021). The Wilcoxon test's statistical evidence, accounting for the small sample size, provides empirical evidence supporting VR training strengthening student learning outcomes through reduced anxiety and increased confidence.

Additionally, student attitudes toward using technology in the course are overwhelmingly positive. One student lost interest after one day, but 11 other students felt VR exposure was fun and valuable. The students’ perspective on the VirtualSpeech public speaking training software was a significant driver of positive insights for deploying VR headsets in future public speaking course offerings.

According to the instructor: “Using technology that fits into a contemporary tech consumption landscape is the best way to reach young students who see school and particularly public speaking as something quite undesirable overall. The potential for this fun toy to be a real and functional tool is high.”

As today’s students are immersed in a world of rising technology and gaming, students can capitalize on this familiarity by creating an immersive learning experience (Li et al., 2023). The connection to digital and gaming experiences fostered enthusiasm and relatability for student participants, making the learning process less intimidating and more engaging.

One limitation of this study is the small sample size. Twenty-one students received headsets, and only 15 completed both the pre-and post-survey. Positive response bias may be shown throughout the results, as students having a better experience with the headset may be more likely to fill out the survey.

A further limitation of this study is the need for a control group. Causal inference of the intervention of VR exposure cannot be stated during this investigation. Students' anxiety reduction and increased confidence levels may be partially, or wholly, attributed to spending six additional weeks in an effective communication course, although it is to be noted that the pre-survey was deployed halfway through the semester. Evaluation of student attitudes toward using the technology signifies that the statistical results found in this paper can, at least partially, be attributed to the intervention of VR headsets.

Gaps also remain in understanding VR's accessibility across diverse populations, its integration with traditional pedagogies, and its potential for adverse effects, such as cyber-sickness. Future research should address these gaps by exploring cost-effective solutions, the pedagogical alignment of VR tools, and strategies for mitigating adverse effects while maximizing inclusivity.

6. FUTURE DIRECTION

The college is taking proactive steps to integrate VR technology into all freshman-level effective speaking courses, aiming to enhance student engagement and public speaking proficiency. The plan focuses on providing increased training for instructors to ensure they are equipped to leverage VR tools effectively, creating a more immersive and interactive learning environment for all students.

Pedagogical response to technological advancements, such as Meta Quest 2's, can and should be a positive integration into higher education. Such integration prepares learners to participate in a digital society and innovate within it, driving VR progress while addressing challenges through informed and technology-enabled solutions.

As VR technology continues to evolve, its potential in education is anticipated to significantly expand across a wide range of disciplines, including communication, STEM (science, technology, engineering, and mathematics), arts, and humanities. This growth will allow for the development of more immersive and interactive learning environments where students can engage with content in new ways. By offering personalized, experiential learning opportunities, VR can tailor educational experiences to individual needs, helping students grasp complex concepts and develop skills more effectively.

7. ACKNOWLEDGEMENT

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8. REFERENCES

Abich, J., Parker, J., Murphy, J. S., & Eudy, M. (2021). A review of the evidence for training effectiveness with virtual reality technology. *Virtual Reality*, *25*(4), 919–933. https://doi.org/10.1007/s10055-020-00498-8

Akbari, O., & Sahibzada, J. (2020). Students' Self-Confidence and Its Impacts on Their Learning Process. *American International Journal of Social Science Research*, *5*(1), 1–15. https://doi.org/10.46281/aijssr.v5i1.462

Alfarsi, G. (2021). A Review of Virtual Reality Applications in an Educational Domai. *International Journal of Interactive Mobile Technologies (iJIM)*, *15*.

Alwafi, G. A., Almalki, S., Alrougi, M., Meccawy, M., & Meccawy, Z. (2022). A Social Virtual Reality Mobile Application for Learning and Practicing English. *International Journal of Interactive Mobile Technologies (iJIM)*, *16*(09), 55–75. https://doi.org/10.3991/ijim.v16i09.28289

Anderson, P. L., Price, M., Edwards, S. M., Obasaju, M. A., Schmertz, S. K., Zimand, E., & Calamaras, M. R. (2013). Virtual reality exposure therapy for social anxiety disorder: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *81*(5), 751–760. https://doi.org/10.1037/a0033559

Bhattacharya, P., Saraswat, D., Savaliya, D., Sanghavi, S., Verma, A., Sakariya, V., Tanwar, S., Sharma, R., Raboaca, M. S., & Manea, D. L. (2023). Towards Future Internet: The Metaverse Perspective for Diverse Industrial Applications. *Mathematics*, *11*(4), Article 4. https://doi.org/10.3390/math11040941

Cao, W., & Yu, Z. (2023). Exploring learning outcomes, communication, anxiety, and motivation in learning communities: A systematic review. *Humanities and Social Sciences Communications*, *10*(1), 1–13. https://doi.org/10.1057/s41599-023-02325-2

Carini, R. M., Kuh, G. D., & Klein, S. P. (2006). Student Engagement and Student Learning: Testing the Linkages*. *Research in Higher Education*, *47*(1), 1–32. https://doi.org/10.1007/s11162-005-8150-9

Clark, R. A., & Jones, D. (2001). A comparison of traditional and online formats in a public speaking course. *Communication Education*, *50*(2), 109–124. https://doi.org/10.1080/03634520109379238

Cui, H., Xu, Z., & Yao, C. (2022). *Will the Metaverse Be the Future of the Internet?* 2165–2170. https://doi.org/10.2991/assehr.k.220504.392

Finn, A. N., Sawyer, C. R., & Schrodt, P. (2009). Examining the Effect of Exposure Therapy on Public Speaking State Anxiety. *Communication Education*, *58*(1), 92–109. https://doi.org/10.1080/03634520802450549

Frisby, B., Kaufmann, R., Vallade, J., Frey, T., & Martin, J. (2020). Using Virtual Reality for Speech Rehearsals: An Innovative Instructor Approach to Enhance Student Public Speaking Efficacy. *Basic Communication Course Annual*, *32*(1). https://ecommons.udayton.edu/bcca/vol32/iss1/6

Frydenberg, M., Yates, D. J., & Noonan, A. (2024, November 1). *Teaching the Metaverse: Applying TPACK to a Multidisciplinary First Year Seminar Course Design. | Information Systems Education Journal | EBSCOhost*. https://doi.org/10.62273/RXFI8909

Grieve, R., Woodley, J., Hunt, S. E., & McKay, A. (2021). Student fears of oral presentations and public speaking in higher education: A qualitative survey. *Journal of Further and Higher Education*, *45*(9), 1281–1293. https://doi.org/10.1080/0309877X.2021.1948509

Gruber, A., & Kaplan-Rakowski, R. (2020). User Experience of Public Speaking Practice in Virtual Reality. In *Cognitive and Affective Perspectives on Immersive Technology in Education* (pp. 235–249). IGI Global. https://doi.org/10.4018/978-1-7998-3250-8.ch012

Halarnkar, P., Shah, S., Shah, H., Shah, H., & Shah, A. (2012). A Review on Virtual Reality. *Internation Journal of Computer Science Issues*, *9*(6), 325–330.

Holly, M., Pirker, J., Resch, S., Brettschuh, S., & Gütl, C. (2021). Designing VR Experiences – Expectations for Teaching and Learning in VR. *Educational Technology & Society*, *24*(2), 107–119.

Hunter, K. M., Westwick, J. N., & Haleta, L. L. (2014). Assessing Success: The Impacts of a Fundamentals of Speech Course on Decreasing Public Speaking Anxiety. *Communication Education*, *63*(2), 124–135. https://doi.org/10.1080/03634523.2013.875213

Hwang, G.-J., & Chien, S.-Y. (2022). Definition, roles, and potential research issues of the metaverse in education: An artificial intelligence perspective. *Computers and Education: Artificial Intelligence*, *3*, 100082. https://doi.org/10.1016/j.caeai.2022.100082

I.C.A, O., & Ebuh, G. (2012). Modified Wilcoxon Signed-Rank Test. *Open Journal of Statistics*, *02*, 172–176. https://doi.org/10.4236/ojs.2012.22019

Kavanagh, S., Luxton-Reilly, A., Wuensche, B., & Plimmer, B. (2017). A systematic review of Virtual Reality in education. *Themes in Science and Technology Education*, *10*(2), 85–119.

Kryston, K., Goble, H., & Eden, A. (2021). Incorporating Virtual Reality training in an introductory public speaking course. *Journal of Communication Pedagogy*, *4*, 133–151. https://doi.org/10.3316/INFORMIT.105960039981701

Lampropoulos, G. & Kinshuk. (2024). Virtual reality and gamification in education: A systematic review. *Educational Technology Research and Development*, *72*(3), 1691–1785. https://doi.org/10.1007/s11423-024-10351-3

Li, M., Ma, S., & Shi, Y. (2023). Examining the effectiveness of gamification as a tool promoting teaching and learning in educational settings: A meta-analysis. *Frontiers in Psychology*, *14*, 1253549. https://doi.org/10.3389/fpsyg.2023.1253549

Lim, M. H., Aryadoust, V., & Esposito, G. (2023). A meta-analysis of the effect of virtual reality on reducing public speaking anxiety. *Current Psychology*, *42*(15), 12912–12928. https://doi.org/10.1007/s12144-021-02684-6

Martirosov, S., Bureš, M., & Zítka, T. (2022). Cyber sickness in low-immersive, semi-immersive, and fully immersive virtual reality. *Virtual Reality*, *26*(1), 15–32. https://doi.org/10.1007/s10055-021-00507-4

Mentzer, K., Frydenberg, M., & Patterson, A. (2024). Are Tech Savvy Students Tech Literate? Digital and Data Literacy Skills of First-Year College Students. *Information Systems Education Journal*, *22*(3), 4–24. https://doi.org/10.62273/MFSD3135

Milgram, P., Takemura, H., Utsumi, A., & Kishino, F. (1995). *Augmented reality: A class of displays on the reality-virtuality continuum* (H. Das, Ed.; pp. 282–292). https://doi.org/10.1117/12.197321

Moro, S. B., Carrieri, M., Avola, D., Brigadoi, S., Lancia, S., Petracca, A., Spezialetti, M., Ferrari, M., Placidi, G., & Quaresima, V. (2016). A novel semi-immersive virtual reality visuo-motor task activates ventrolateral prefrontal cortex: A functional near-infrared spectroscopy study. *Journal of Neural Engineering*, *13*(3), 036002. https://doi.org/10.1088/1741-2560/13/3/036002

Muthmainnah, M., Khang, A., Yakin, A. A., Oteir, I., & Alotaibi, A. N. (2023). An Innovative Teaching Model: The Potential of Metaverse for English Learning. In *Handbook of Research on AI-Based Technologies and Applications in the Era of the Metaverse* (pp. 105–126). IGI Global. https://doi.org/10.4018/978-1-6684-8851-5.ch005

Netta, A., Trisnawati, I. K., & Helmanda, C. M. (2020). Indonesian EFL students' strategies in dealing with speaking anxiety in public speaking course. *ACCENTIA: Journal of English Language and Education*, *1*(1), 1–9. https://doi.org/10.37598/accentia.v1i1.807

Noah, N., & Das, S. (2021). Exploring evolution of augmented and virtual reality education space in 2020 through systematic literature review. *Computer Animation and Virtual Worlds*, *32*(3–4), e2020. https://doi.org/10.1002/cav.2020

Patterson, A., Mocarsky, M., Cho, J., Harmon, O., & Calvert, C. (2023). Teaching Data Literacy and Sports Economic Fundamentals Using Fantasy Sports. *Business Education Innovation Journal*, *15*(1).

Ramesh, U. V., Harini, A., Divya Gowri, Ch. S., Vyshnavi Durga, K., Druvitha, P., & Siva Kumar, K. (2022). Metaverse: Future of the Internet. *International Journal of Research Publication and Reviews*, *3*(2), 93–97.

Reeves, R., Elliott, A., Curran, D., Dyer, K., & Hanna, D. (2021). 360° Video virtual reality exposure therapy for public speaking anxiety: A randomized controlled trial. *Journal of Anxiety Disorders*, *83*, 102451. https://doi.org/10.1016/j.janxdis.2021.102451

Ritterbusch, G. D., & Teichmann, M. R. (2023). Defining the Metaverse: A Systematic Literature Review. *IEEE Access*, *11*, 12368–12377. IEEE Access. https://doi.org/10.1109/ACCESS.2023.3241809

Roebken, H. (2007). The Influence of Goal Orientation on Student Satisfaction, Academic Engagement and Achievement. *Electronic Journal of Research in Educational Psychology*, *5*(13).

Saeed, A., Foaud, L., & Fattouh, L. (2017). Environments and System Types of Virtual Reality Technology in STEM: A Survey. *International Journal of Advanced Computer Science and Applications*, *8*(6). https://doi.org/10.14569/IJACSA.2017.080610

Taheri, S. M., & Hesamian, G. (2013). A generalization of the Wilcoxon signed-rank test and its applications. *Statistical Papers*, *54*(2), 457–470. https://doi.org/10.1007/s00362-012-0443-4

Wang, Q., Tang, L., & Wang, Y. (2023). Potential Applications of the Metaverse in Higher English Education. *Open Journal of Social Sciences*, *11*(1), Article 1. https://doi.org/10.4236/jss.2023.111031

Wohlgenannt, I., Simons, A., & Stieglitz, S. (2020). Virtual Reality. *Business &*

Information Systems Engineering, *62*(5), 455–461. https://doi.org/10.1007/s12599-020-00658-9

World Economic Forum. (2022). *The future of education is in experiential learning and VR*. https://www.weforum.org/agenda/2022/05/the-future-of-education-is-in-experiential-learning-and-vr

Yuan, J., Liu, Y., Han, X., Li, A., & Zhao, L. (2023). Educational metaverse: An exploration and practice of VR wisdom teaching model in Chinese Open University English course. *Interactive Technology and Smart Education*, *20*(3), 403–421. https://doi.org/10.1108/ITSE-10-2022-0140

Zhou, H., Fujimoto, Y., Kanbara, M., & Kato, H. (2021). Virtual Reality as a Reflection Technique for Public Speaking Training. *Applied Sciences*, *11*(9), Article 9. https://doi.org/10.3390/app11093988

APPENDIX

Label in Paper	Question Asked	Response Items
Anxiety	I feel anxious before giving a public speech or speaking in a public setting	Strongly disagree, disagree, somewhat disagree, neither agree nor disagree, somewhat agree, agree, strongly agree
Comfort	I feel comfortable speaking in front of a group of classmates	same as above
Confidence	I am confident in my ability to deliver a presentation clearly with good vocal projection	same as above
Satisfaction	I have been satisfied with my past performance when delivering a public speech	same as above
Importance	I feel effective communication is important for my future job	same as above
Enjoyment	I enjoy the effective communication course	same as above

Likert scale values were coded as follows:

Strongly disagree = -3, Disagree = -2, Somewhat disagree = -1, Neither agree not disagree = 0 Somewhat agree = 1, Agree = 2, Strongly agree = 3

Table 1: Quantitative Survey Questions

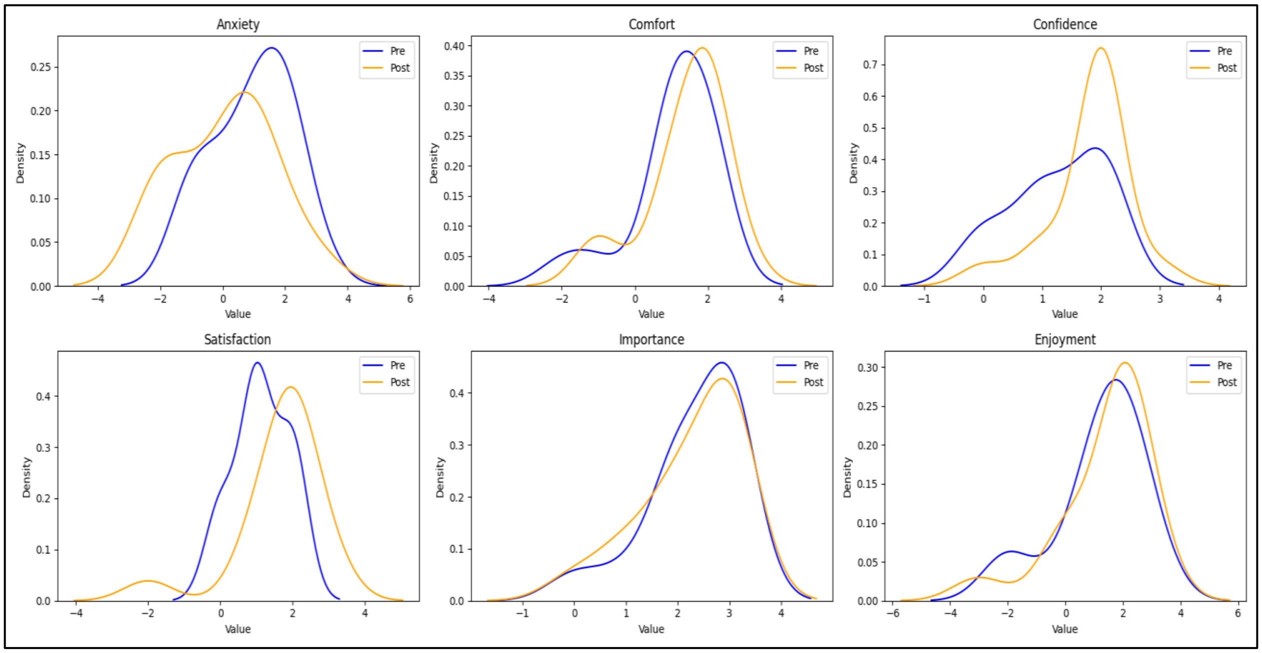

Figure 1: Distribution of Quantitative Questions

Teaching Case

Leveraging Topic Modeling to Predict and Prevent Employee Attrition

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Abstract

This case study examines employee attrition, its detrimental effects on businesses, and the potential of data analytics to address this challenge. By employing Latent Dirichlet Allocation (LDA), a sophisticated NLP technique, we delve into the underlying reasons for employee departures. Additionally, we explore using RapidMiner to develop predictive models to forecast employee churn, empowering organizations to proactively implement retention strategies.

Keywords: Attrition, Turnover, Latent Dirichlet Allocation, Human Resources, Retention, RapidMiner

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Leveraging Topic Modeling to Predict and Prevent Employee Attrition

Frank Lee and Alex Algarra

1. INTRODUCTION

Employee Attrition

Understanding why employees leave empowers organizations to retain their top talent. By addressing employee concerns and improving the work environment, organizations can keep their best people, giving them a competitive advantage. Employee turnover data (attrition) is a valuable tool for future planning. It helps identify potential workforce gaps and allows for targeted development programs. This way, organizations can groom successors for critical roles, ensuring a smooth transition and continued success (Demirkaya, et al., 2022).

Understanding the root causes of employee attrition equips organizations with a powerful weapon: targeted retention strategies. This reduces the financial burden of replacing lost talent and maintains a competitive edge by keeping your best people on board. Researchers can leverage this knowledge to identify industry-specific attrition trends. This allows organizations to benchmark their own situation, comparing their attrition rates and practices to industry standards and best practices. This valuable comparison helps identify areas for improvement and implement the most successful retention strategies within their specific industry.
While attrition's impact on businesses is clear, its reach extends far beyond the bottom line. It can lead to broader social issues like higher unemployment and job insecurity. By studying attrition's contributing factors, researchers can offer valuable insights to policymakers, informing them on policies that promote job creation and retention. But it is not just jobs on the line. Attrition can also affect employee well-being, affecting both physical and mental health. Researchers can help organizations develop healthier and more supportive work environments by understanding the reasons behind employee departures, ultimately benefiting everyone involved.

Latent Dirichlet Allocation (LDA)

Latent Dirichlet Allocation (LDA) is a probabilistic generative model used in Natural Language Processing (NLP) for topic modeling (Blei, et al., 2003). LDA aims to discover the hidden thematic structure of text data and to represent this structure in an interpretable form. This method allows people to identify the underlying topics in documents. Now, to understand how LDA works, it is helpful to break down the model into its parts:

- Word: An atomic unit of meaning.
- Document: A collection of words.
- Corpus: A collection of documents
- Topic: A set of words likely to co-occur in documents.

The basic idea behind Latent Dirichlet Allocation is that each document in the constructed corpus can be a mixture of topics (Blei, et al., 2003). A topic is a distribution over sets of words, and a document is an amalgam of topics, each contributing a particular weight. Each topic is a probabilistic distribution over a set of words. Strictly speaking, the LDA algorithm assumes each document is a probabilistic mixture of hidden topics. The LDA model assumes that each document is created as follows:

1. Choosing the number of words in the document.
2. Choosing a distribution over topics for the document from the Dirichlet distribution.
3. And, for each word in the document:
   - Choosing a topic from the topic distribution.
   - Choosing a word from the topic distribution.

RapidMiner

RapidMiner is a data science platform that allows users to perform a wide range of data preparation, machine learning, and predictive modeling tasks—providing a drag-and-drop interface that allows users to quickly build and perform complex analyses without extensive programming knowledge.

One of the benefits of RapidMiner is its ability to handle large datasets, as it allows the user to process data in memory or on disk. The platform also provides visualization and reporting tools to help users understand the data and thus communicate their findings. Businesses and organizations in various industries, including finance, healthcare, and retail, use RapidMiner. It is also popular among data scientists and researchers who must perform complex analyses on large datasets.

Learning Objectives
By completing this assignment, you will be able to:

- Understand the methodology used to collect and analyze text data.
- Understand the concept of Latent Dirichlet allocation (LDA).
- Analyze the attrition of the organization's employees through data analytics.
- Identify the key topics and themes that are driving this trend.
- Develop critical thinking skills and interpret the findings to recommend employee retention and engagement solutions.

2. CASE BACKGROUND

Case Text
Even before working in human resources, Maggie has always been deeply passionate about data. She knew that data could provide valuable insights into human behavior and could be used to improve decision-making across a variety of fields. She has a degree in statistics and has completed several online courses in data science and machine learning. Though Maggie was passionate about data from the start, her admiration for analytics grew tenfold when she began working in HR. After several years in various roles, Maggie realized the power of data analytics and how it could be applied to ensure that the employees within her company were more satisfied with their own work. Maggie combined her love of data and desire to support her peers in the workplace to solve some of the industry's most pressing challenges, such as employee turnover and engagement.

Maggie stays current on industry blogs, attends conferences, and networks with other passionate HR professionals who share her interest in data-driven decision-making. So, when her boss, the Chief Human Resources Officer, tasked her with investigating the company's high attrition rates, Maggie was thrilled to apply her data background to the employees she worked alongside. She knew this was a complex problem requiring a deep understanding of the underlying factors driving employee turnover.

Maggie began by gathering all the data on employee turnover, including exit interviews, employee satisfaction surveys, and performance data. She also took a comprehensive approach by contacting other departments across the company to understand better the broader context in which the attrition occurred. After all, how did attrition and turnover impact the company as a whole?

As she began to dive into the data, Maggie noticed several patterns emerging. She saw a higher turnover rate among employees who had been with the company for less than a year. Many of these employees cited a lack of career development opportunities as a reason for leaving. She also saw a strong correlation between employee engagement and turnover, with disengaged employees more likely to leave.

Armed with these insights, Maggie began to develop a plan to address the underlying issues driving the attrition problem that her peers faced. She proposed a series of initiatives to improve career development opportunities, enhance employee engagement, and strengthen the company's culture and values. For example, Maggie recommended that the company introduce a formal mentorship program to help new employees navigate their roles and develop their careers. Additionally, the program would foster engagement for new employees.

She also suggested that the company invest in recurring training programs and skill-building workshops to help employees acquire new skills and advance in their careers based on their interests. Additionally, she recommended that the company improve its communication and feedback processes to help employees feel more engaged and connected to the company's goals and values.

With the support of her boss and other senior leaders, Maggie implemented these initiatives, closely monitoring their impact on employee turnover rates. Over time, she saw a significant reduction in attrition, with employees reporting higher levels of engagement, more significant career development opportunities, and a stronger sense of connection to the company's mission and values.

Maggie felt immensely proud of her work and its impact on the company and its employees, especially because it included individuals she worked to support every day. She realized that her passion for data analytics had not only helped her to solve a critical business problem but had also enabled her to make a meaningful difference in people's lives. Maggie continued to explore new ways to apply data analytics to HR, and her work became a model for other companies seeking to improve employee retention and engagement.

The Data Source
The data set contains 1,155 responses from employees who have quit the organization labeled "Quit_Reason" and their respective "Employee_ID," "Hire_Date," and "Quit_Date." The responses were collected through an exit survey conducted by the organization. This data set can be used for various analyses, such as identifying the most common reasons for employee attrition, exploring patterns in the reasons for quitting, and predicting which employees are likely to leave the organization based on their tenure. The attributes within the data set are as follows:

- Employee_ID: A unique identifier of each employee.
- Quit_Reason: A text field where employees could explain why they quit the organization.
- Hire_Date: The date the organization hired the employee.
- Quit_Date: The date the employee quit the organization.

The research problem of the organization’s attrition is to investigate why employees leave their jobs in record numbers. This phenomenon has been observed and has caused organizational concerns regarding employee retention and engagement, particularly in the Human Resources field. The research gap in this area is the lack of understanding of the critical topics and themes driving the trend, making it difficult for organizations to develop effective retention strategies.

The importance of this research problem is twofold. First, it provides a better understanding of the factors driving the attrition trend, which can help organizations develop more effective employee retention strategies. Second, it contributes to the body of knowledge in the Human Resources field, particularly in data analytics, and can be used as a reference for future research.

3. PROJECT ACTIVITY

This exercise aims to identify the key reasons behind the resignation trend by analyzing the content of 1,155 employee responses when asked why they have decided to leave the company. Respectively, the exercise aims to:

- Identify the key topics and themes related to the resignations within the company.
- Develop a better understanding of the factors driving the trend, such as job satisfaction, work-life balance, compensation, and employee benefits.
- Provide recommendations to organizations on improving employee retention and engagement based on the study's findings.

The following steps will help guide you along during the data analysis. Please make sure to follow each of the steps in order.

1. Open RapidMiner Studio on your computer. The RapidMiner Studio window will appear. A new window will ask you to select a template for your new process. Select the "Blank Process" option to open a blank process and click the "Create" button. (Appendix A, Figure 1).

2. Once the blank process is open, you will see tabs in the console, including the repository, process, operators, parameters, background monitor, and help. (Appendix A, Figure 2)

3. To import the "Employee_Attrition" dataset into RapidMiner, click on the "File" option in the top menu bar. In the dropdown menu that appears, click on "Import Data." A new window will appear; select the "Import File" option in this window. In the "Select File" window that appears, navigate to the location where the "Employee_Attrition" dataset is saved to your computer. Then, click the "Open" button, and in the "Select Table" window that appears, make sure the "First row contains attribute names" checkbox is selected. Finally, click on the "Finish" button. The "Employee_Attrition" dataset should now appear in the Repository tab under the "Data" folder. We can drag it onto the process canvas to start working with it in the workflow. (Appendix A, Figure 3).

4. Before we get started building the LDA process, we must save the process. In the RapidMiner Studio window, ensure the process is open and visible on the process canvas. In the top menu bar, click on the "File" option; in the dropdown menu that appears, click "Save As.". A new window will appear, asking for the location and name of the saved process. Choose the location under the "Processes" tab and name the file "Attrition_LDA." Once the process is saved, it is accessible moving forward by navigating to the file's location and double-clicking. (Appendix A, Figure 4).

5. The process canvas is the large central area in the RapidMiner Studio window where the data analysis workflows are built. Click and drag the "Employee_Attrition" dataset from the Repository panel under the data folder onto the process canvas. The dataset will now appear as a blue box on the canvas, as a "Retrieve" operator with its name displayed at the top. It is possible to connect the "Employee_Attrition" dataset to operators on the canvas to build your data analysis workflow (Appendix A, Figure 5).

6. Connect the "Employee_Attrition" dataset to the results port of the process canvas on the right-hand side. A blue circle on the left side of the operator box will represent the input port. To do this, click on the blue circle on the right side of the dataset box and drag the connection arrow to the results port (Appendix A, Figure 6).

7. We can examine the dataset attributes once the dataset is connected to the results port. To do this, click on the "Run Process" button in the console's upper left corner, displaying a data preview with columns representing the dataset attributes. We can see the dataset contains the text attribute "Quit_Reason," which are the responses given by employees when asked why they have decided to leave the company (Appendix A, Figure 7).

8. The Select Attributes operator is used to specify which attributes to include or exclude from the dataset and can help simplify the dataset and remove unnecessary or redundant columns. To specify the Select Attributes operator to select the "Quit_Reason" attribute of the "Employee_Attrition" dataset, follow these steps: (Appendix A, Figure 8)

- Search for the operator and drag a Select Attributes operator onto the process canvas from the "Operators" panel on the left side of the screen.
- Connect the "Employee_Attrition" dataset to the input port of the Select Attributes operator. To do this, click on the blue circle on the right side of the dataset box and drag the connection arrow to the input port of the Select Attributes operator.
- Double-click on the Select Attributes operator to open its configuration window.
- In the configuration window, a list of all the attributes in the dataset appears. To select the "Quit_Reason" attribute, click the checkbox next to its name in the list.
- Once the attribute has been selected, click "Apply" to save your changes and close the configuration window.
- The output of the Select Attributes operator will be a new dataset containing only the selected attributes.

9. The Nominal to Text operator converts nominal values (categorical data) in a dataset into text values and can help prepare data for certain types of analysis or visualization. To add the Nominal to Text operator into the process, follow these steps: (Appendix A, Figure 9).

   - Search for the operator and drag the Nominal to Text operator onto the process canvas from the "Operators" panel.
   - Connect the output of the Select Attributes operator to the input port of the Nominal to Text operator.
   - Double-click on the Nominal to Text operator to open its configuration window.
   - The configuration window lists all the attributes in the input dataset. Please select the "Quit_Reason" attribute we want to convert by checking its checkbox.
   - Next, select the "Conversion" tab in the configuration window. Here, it is possible to specify how to convert the nominal values to text. For example,

replace each value with a specific text string or a corresponding numerical code.

- Once the conversion options have been specified, click "Apply" to save the changes and close the configuration window.
- The output of the Nominal to Text operator will be a new dataset with the selected attribute converted from nominal to text.

10. The "Multiply" operator takes the example set from the input port and delivers copies to the output ports. Each connected port creates an independent copy. So, changing one copy does not affect other copies. For example, suppose there is an input example set with 1,000 examples. In that case, use the "Multiply" operator with a factor of 3 to create a new set of 3,000 examples. This operation can generate data for testing or training purposes. To add the Multiply operator in the process, follow these steps: (Appendix A, Figure 10)

- Search for the operator and drag and drop the "Multiply" operator from the "Operators" panel onto the canvas.
- Connect the output of the "Nominal to Text" operator to the input of the "Multiply" operator. To do this, click and drag the output port of the "Nominal to Text" operator to the input port of the "Multiply" operator.

11. The "Process Documents from Data" operator in RapidMiner is used to preprocess text data and extract meaningful information. This operator takes a text input file or example set as input and generates word vectors from string attributes as output. To add the Process Documents from the Data operator into the process, follow these steps: (Appendix A, Figure 11)

- Search for the operator and drag and drop the "Process Documents from Data" operator from the "Operators" panel onto the canvas.
- Connect the output of the "Multiply" operator to the input of the "Process Documents from Data" operator. To do this, click and drag the output port of the "Multiply" operator to the input port of the "Process Documents from Data" operator.
- Double-click the "Process Documents from Data" operator to open its parameters dialog. Configuring the settings for text preprocessing, feature extraction, and other options is possible.

12. The Process Documents from Data operator contains a subprocess and a subprocess is a smaller, self-contained process that can be used as a building block within a larger process. Subprocesses can be thought of as subroutines or functions in programming. We will be adding the "Tokenize", "Transform Cases", "Filter Stopwords", "Filter Tokens", and "Stem (Porter)" operators to the "Process Documents from Data" subprocess. To begin building the subprocess within the operator, follow these steps: (Appendix A, Figure 12)

- Double-click the "Process Documents from Data" operator to open its subprocess.
- In the "Search for Operators" section, click and drag the "Tokenize", "Transform Cases", "Filter Stopwords", "Filter Tokens", and "Stem (Porter)" operators and connect them to results tab.

13. Furthermore, we must specify the parameters for each operator. To do this click on each operator and navigate to the parameters section. The following operator’s parameters are listed from left to right of the subprocess.

- The "Tokenize" operator splits a text string into individual words or tokens, takes a text attribute as input, and generates a new attribute containing the tokens as separate examples. (Appendix A, Figure 13).
- The "Transform Cases" operator in RapidMiner converts the case of a text attribute. It takes a text attribute as input and generates a new attribute that contains the text with the case transformed according to the selected mode, either uppercase or lowercase. (Appendix A, Figure 14).
- Stopwords are words that are commonly used in a language but do not carry much meaning or information, such as "the," "and," "a," and so on. Removing stopwords from a text attribute can reduce noise in the data

and improve the accuracy of subsequent analyses. (Appendix A, Figure 15).

- The "Filter Tokens (by Length)" operator in RapidMiner removes tokens outside a specified range of character lengths. This can be useful for removing very short or very long tokens that may not be relevant to the analysis. (Appendix A, Figure 16).
- The "Stem (Porter)" operator in RapidMiner reduces words to their base or root form, also known as stemming, and is essential for text mining because it can help to normalize the text and reduce the dimensionality of the data. (Appendix A, Figure 17).

14. Now, we need to navigate back to the main process window. The "Wordlist to Data" operator converts a list of words into a data set and can be helpful when there is a pre-defined list of words you want to filter before reporting it. To add the Wordlist to the Data operator into the process, follow these steps: (Appendix A, Figure 18).

- Locate the "Wordlist to Data" operator in the "Text Processing" category of the RapidMiner Operators panel.
- Drag the "Wordlist to Data" operator onto the Process canvas.
- Connect the output of the "Process Documents from Data" operator to the "Wordlist to Data" operator by clicking and dragging the output arrow of the former to the input port of the latter.

15. The "Set Role" operator defines attributes' roles in a data set and allows you to specify whether each attribute is a regular, label, id, or weight attribute. Here are the steps to add the "Set Role" operator to your process and connect it to the output of the "Multiply" operator: (Appendix A, Figure 19).

- Locate the "Set Role" operator in the "Data Transformation" category of the Operators panel.
- Drag the "Set Role" operator onto the Process canvas.
- Connect the output of the "Multiply" operator to the "Set Role" operator by clicking and dragging the output arrow of the former to the input port of the latter.
- In the "Set Role" operator, it is possible to specify the role of each attribute in the input data set by selecting the appropriate role from the drop-down menu next to each attribute.
- Specify the role of “Quit_Reason” to “label” and click apply.

16. The "Extract Topics from Data (LDA)" operator in RapidMiner finds topics using the LDA method. To add the "Extract Documents from Data (LDA)" operator into your RapidMiner process and connect it to the "Set Role" operator, you can follow these steps: (Appendix A, Figure 20).

- Drag the "Extract Topics from Data (LDA)" operator from the "Text Processing" folder in the "Operators" panel and drop it onto the process canvas.
- Connect the output of the "Set Role" operator to the input of the "Extract Topics from Data (LDA)" operator.

17. Once you have completed your process, you can connect the outputs of the “Extract Topics from Data (LDA)” and the “Wordlist to Data” operators to the results output and run the process (Appendix A, Figure 21).

18. After the process has completed running, RapidMiner should automatically show the Results tab. There should be six individual results, including two example sets, performance vector, LDA prediction, WordList, and result history (Appendix A, Figure 22).

- Performance Vector (Extract Topics from Data (LDA)): Provides several metrics to evaluate the performance of the topic model generated by the operator. These metrics include (Appendix A, Figure 25)

- LDA Prediction (Extract Topics from Data (LDA)): Provides several performance metrics and information about the topics and documents in the dataset. (Appendix A, Figure 26)

- WordList (Process Documents from Data): Generates a list of all the unique words present in the input documents along with their total occurrences across all the documents and document occurrences, i.e., the number of documents in which a particular word occurs. (Appendix A, Figure 27)

4. LDA TOPICS

Topic 0	Events, Social, Listen, Action, Take, Activities, Hold, Satisfaction, Improve, Follow
Topic 1	Pay, Pension, Careerpromotions, Better, Incentives, Benefit, Communication, Higher, Perk, Raises
Topic 2	Insurance, Package, Compensation, Healthcare, Better, Personal, Less, Get, Rid, Care
Topic 3	Employees, Work, Good, Management, Keep, Works, Recognize, Could, Communication, Team
Topic 4	Employees, Treat, Respect, Offer, Listen, Benefits, Reward, Listen, Childcare, Support
Topic 5	People, Reimbursement, Hours, Education, Training, Flexible, Need, Career, Working, Job
Topic 6	Office, Really, Going, Organization, Part, Would, Outside, See, Feel, Previous
Topic 7	Company, Outings, Like, Would, Get, Employees, Sponsored, Benefits, Think, Offer
Topic 8	Time, Vacation, Rollover, Increase, Bonus, Raises, Standard, Industry, Nothing, Performance
Topic 9	Jobs, Raises, Performance, Employees, Management, Give, Better, Done, Good, Year

Table 1. LDA Topic Table

Topic Descriptions

Topic 0 (Employee Engagement and Development)

This topic seems to be centered around employee engagement and satisfaction, with words like "satisfaction," "improve," and "follow" suggesting a focus on improving employee well-being. The inclusion of words like "events," "social," and "activities" suggests that the topic also encompasses opportunities for social and professional development, which could help to improve employee engagement and job satisfaction. Finally, the use of words like "listen," "action," and "hold" suggests a focus on taking action to address employee concerns and hold events or activities that are tailored to their needs and interests.

Topic 1 (Motivation and Retention)

This topic seems to be centered around employee compensation and benefits, with words like "pay," "pension," "incentives," and "perks" suggesting a focus on providing attractive compensation packages to retain and motivate employees. The inclusion of words like "career promotions," "better," and "higher" suggests that the topic also encompasses opportunities for career advancement and growth. Finally, using words like "communication" suggests a focus on transparent and effective communication between employees and management regarding compensation and benefits.

Topic 2 (Healthcare for Improved Well-being)

This topic seems to be centered around employee benefits and healthcare, with words like "insurance," "compensation," "healthcare," and "personal," suggesting a focus on providing employees with access to healthcare services and comprehensive benefits packages. Words like "better" and "less" suggest that the topic also encompasses improving employee benefits' quality and affordability. Finally, using words like "get rid" and "care" suggests a focus on addressing employee concerns related to healthcare and well-being.

Topic 3 (Effective Management and Team Communication)

This topic seems to be centered around the importance of effective management and team communication in retaining employees, with words like "employees," "work," "management," and "team" suggesting a focus on teamwork and collaboration. The use of words like "keep," "works," and "recognize" suggests that the topic also encompasses efforts to retain and recognize good employees. Finally, using words like "could" and "communication" suggests a focus on improving communication and feedback channels between employees and management for increased retention and job satisfaction.

Topic 4 (Employee Well-being and Supportive Culture)

This topic seems to be centered around creating a supportive work culture that prioritizes employee well-being, with words like "employees," "treat," "respect," "benefits," and "childcare," suggesting a focus on offering benefits and support to employees. Using words like "reward" and "listen" suggests that the topic also encompasses efforts to recognize and respond to employee needs and concerns. Finally, using words like "support" suggests a focus on creating a workplace environment that supports and empowers employees to succeed, which can lead to improved retention rates.

Topic 5 (Career Development and Work-Life Balance)
This topic seems to be centered around offering opportunities for career development and work-life balance to employees, with words like "education," "training," "career," "flexible," and "working," suggesting a focus on employee growth and development. The use of words like "reimbursement," "hours," and "need" suggests that the topic also encompasses efforts to provide employees with the resources they need to advance their careers, such as financial support and flexible scheduling. Finally, using words like "job" suggests a focus on retaining employees by offering fulfilling and rewarding work experiences that align with their career goals and priorities.

Topic 6 (Organizational Culture and Employee Satisfaction)
This topic seems to be focused on the overall culture and environment within the organization, with words like "office," "organization," and "feel" suggesting a focus on the physical workplace and the atmosphere within it. The use of words like "going," "see," and "outside" suggests a focus on how employees experience and interact with the organization beyond the physical workspace. Using words like "really" and "previous" suggests that this topic may also encompass employee perspectives on organizational changes or improvements over time. Finally, using words like "part" and "would" suggests that this topic may also encompass employee opinions on their role within the organization and how well it aligns with their interests and goals.

Topic 7 (Benefits and Perks)
This topic seems to be focused on the various benefits and perks offered to employees by the company, with words like "company," "employees," and "sponsored" suggesting a focus on the employer-employee relationship. The use of words like "outings," "like," and "get" suggests a focus on recreational or social activities that the company may offer as a benefit or perk. Additionally, the use of words like "think" and "offer" suggests that this topic may also encompass employee opinions on the adequacy and effectiveness of the benefits and perks offered by the company.

Topic 8 (Compensation)
This topic seems to be focused on various forms of compensation and benefits offered to employees, with words like "time," "vacation," "roll over," "increase," "bonus," and "raises" suggesting a focus on financial compensation. Using words like "standard" and "industry" suggests that this topic may also encompass comparisons to industry standards or expectations for compensation and benefits. Additionally, using words like "performance" and "nothing" suggests that this topic may include employee opinions on how their compensation and benefits are tied to their performance and contribution to the company.

Topic 9 (Performance and Career Growth)
The topic contains words related to employee performance, career growth, and rewards for good performance, such as jobs, raises, performance, better, done, good, and year. The words suggest that employees seek opportunities to improve their performance and advance in their careers and expect to be rewarded for their efforts.

5. PROJECT REPORT

In this project report, you will comprehensively analyze employee attrition and its impact on businesses. Ensure the report includes an executive summary, introduction, data collection, data preparation, methodology, conclusion, reference, and appendix. Focus on interesting, surprising, or important results in your discussion, interpret the results with detailed information, and explore the consequences or implications of your findings. In the results and discussion section, concentrate on the most interesting, surprising, or important results obtained from the analysis. Interpret the 10 topics found in the LDA modeling process and explain your reasoning behind the interpretation. Discuss the consequences or implications of these results and, if the findings are unexpected, explore possible explanations, such as other factors not included in the analysis.

Conclude by summarizing the project's main points and key takeaways, highlighting the value of data analytics in addressing HR challenges and improving employee retention and engagement. Cite all sources used in the references section and include any supplementary materials, such as tables, charts, or code, in the appendix. By following this structure and focusing on the most relevant results, your project report will thoroughly analyze employee attrition and offer valuable insights for improving employee retention and engagement.

6. REFERENCES

Blei, D. M., Ng, A. Y., & Jordan, M. I. (2003). Latent Dirichlet Allocation. The Journal of Machine Learning Research, 3, 993–1022.

Demirkaya, H., Aslan, M., Güngör, H., Durmaz, V., & Rodoplu Şahin, D. (2022). Covid-19 and quitting jobs. Frontiers in Psychology, 13. https://doi.org/10.3389/fpsyg.2022.916222

APPENDIX A
Guided Step-by-Step Figures

Due to the file size limit, not all Figures in the Appendix are displayed here. You can download the full Appendix at https://tinyurl.com/iscap2024.

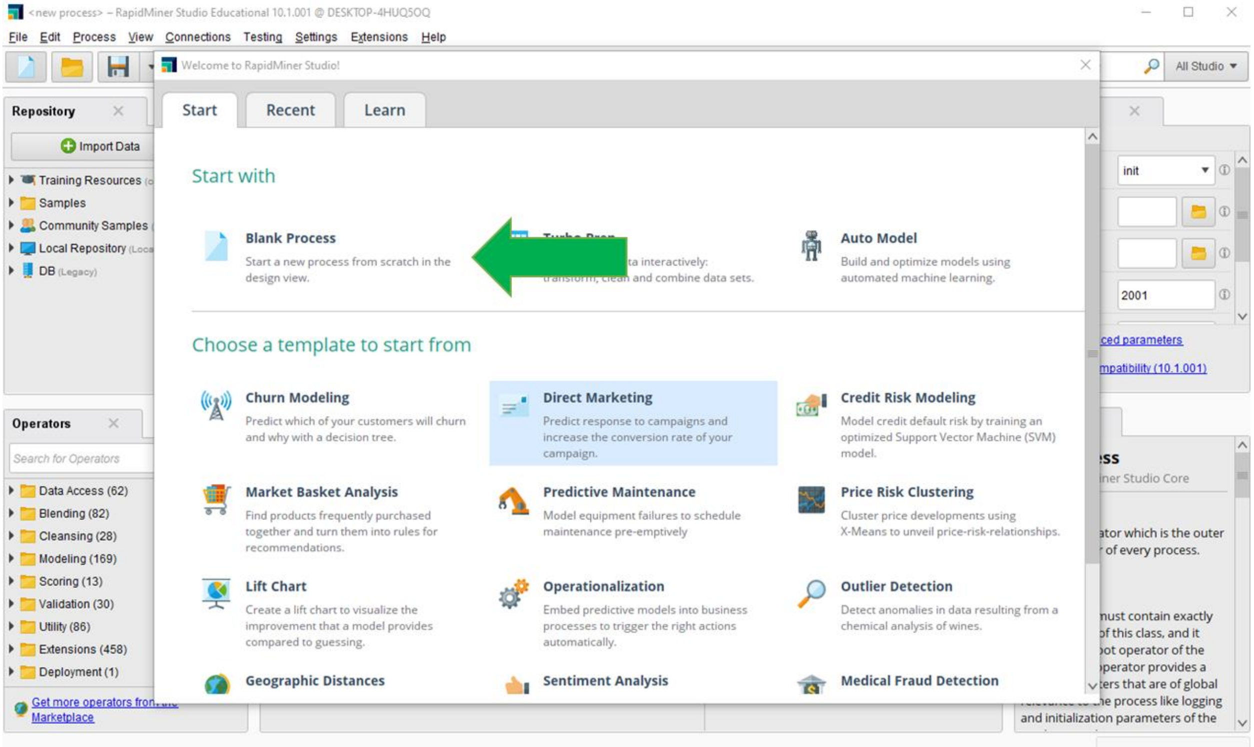


Figure 1. Open blank process

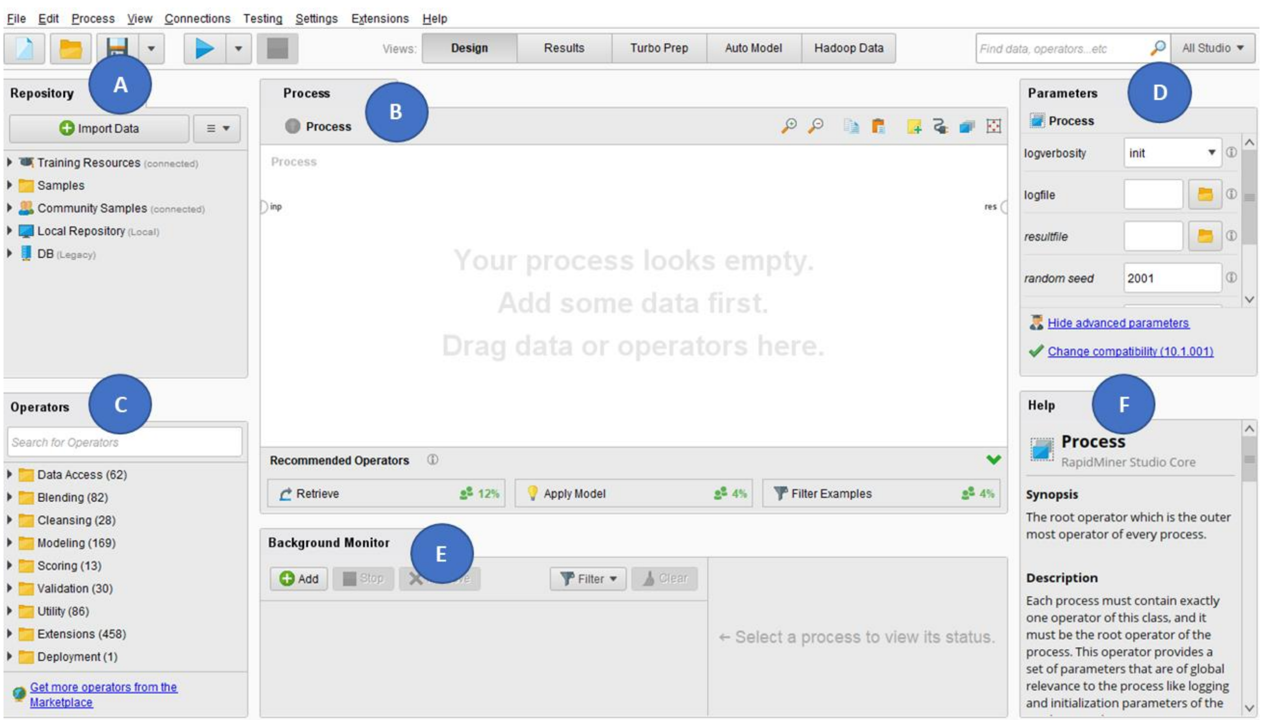


Figure 2. Introduction to the RapidMiner console.

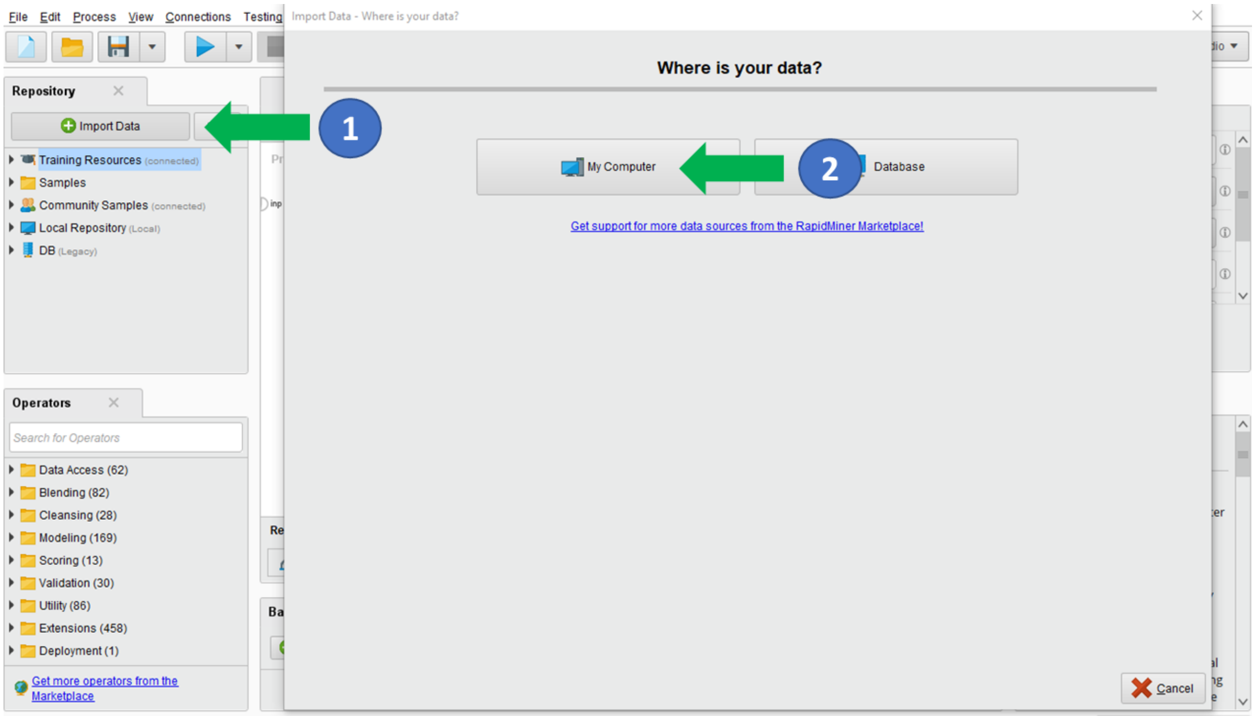


Figure 3. Import the "Employee_Attrition" data set into RapidMiner.

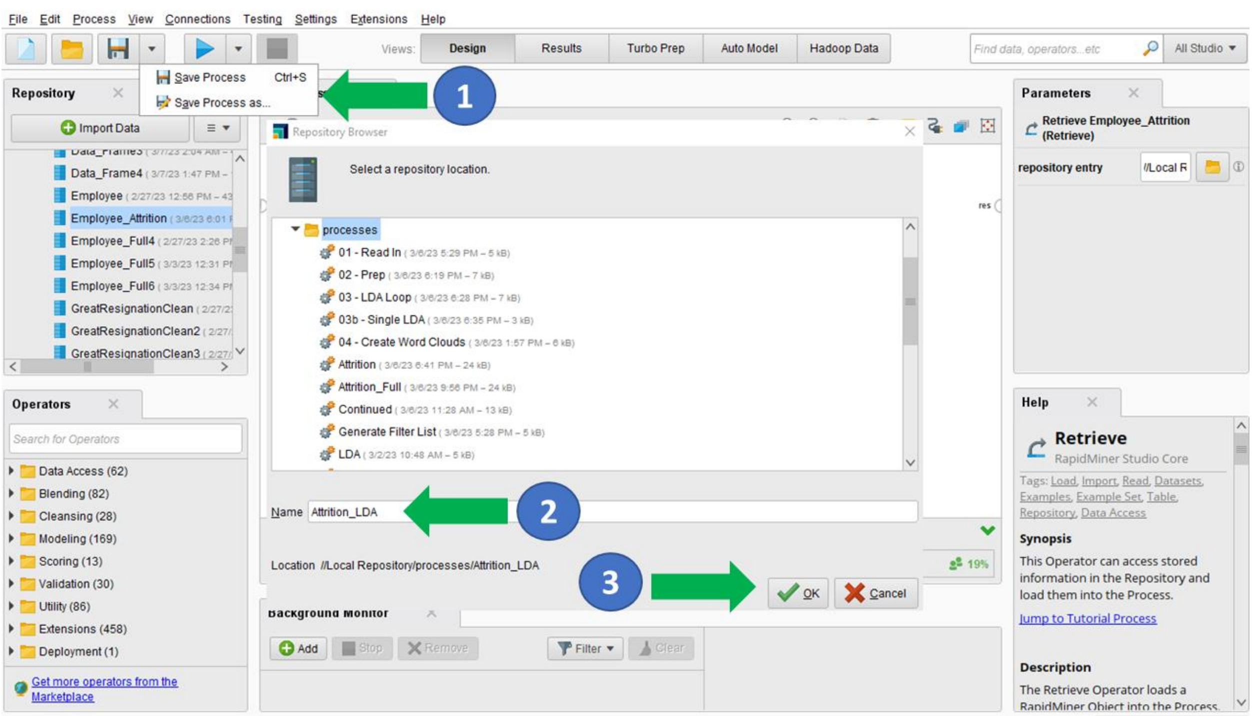


Figure 4. Save the process as "Attrition_LDA"

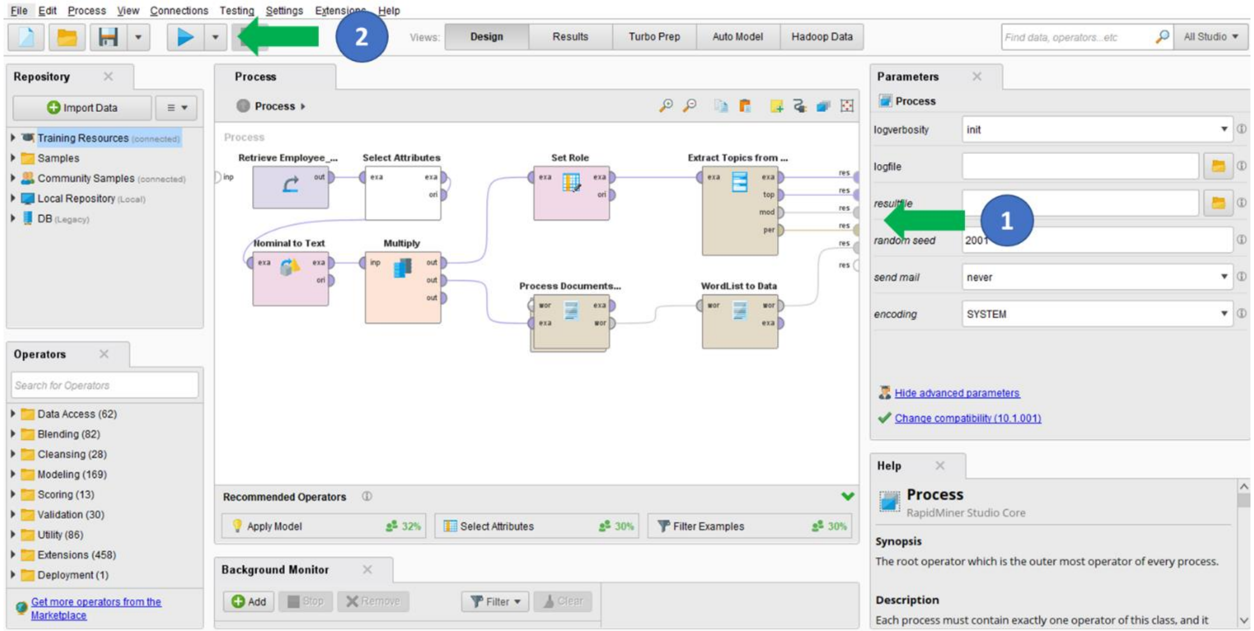


Figure 21. Connect all outputs to the result ports and click "Run Process."

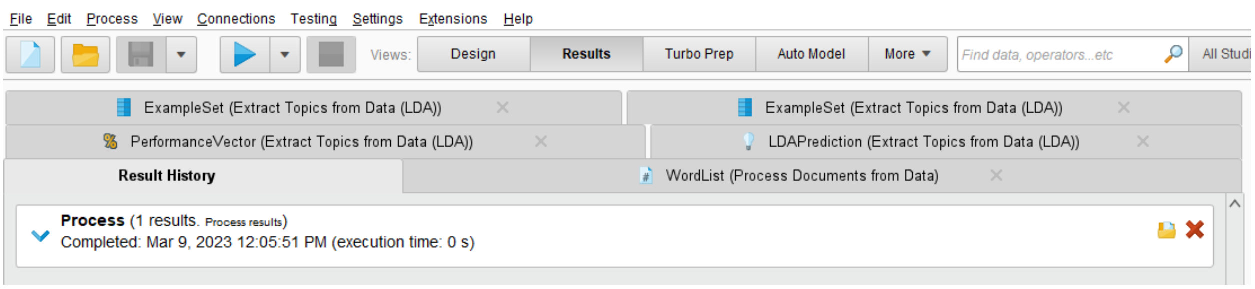
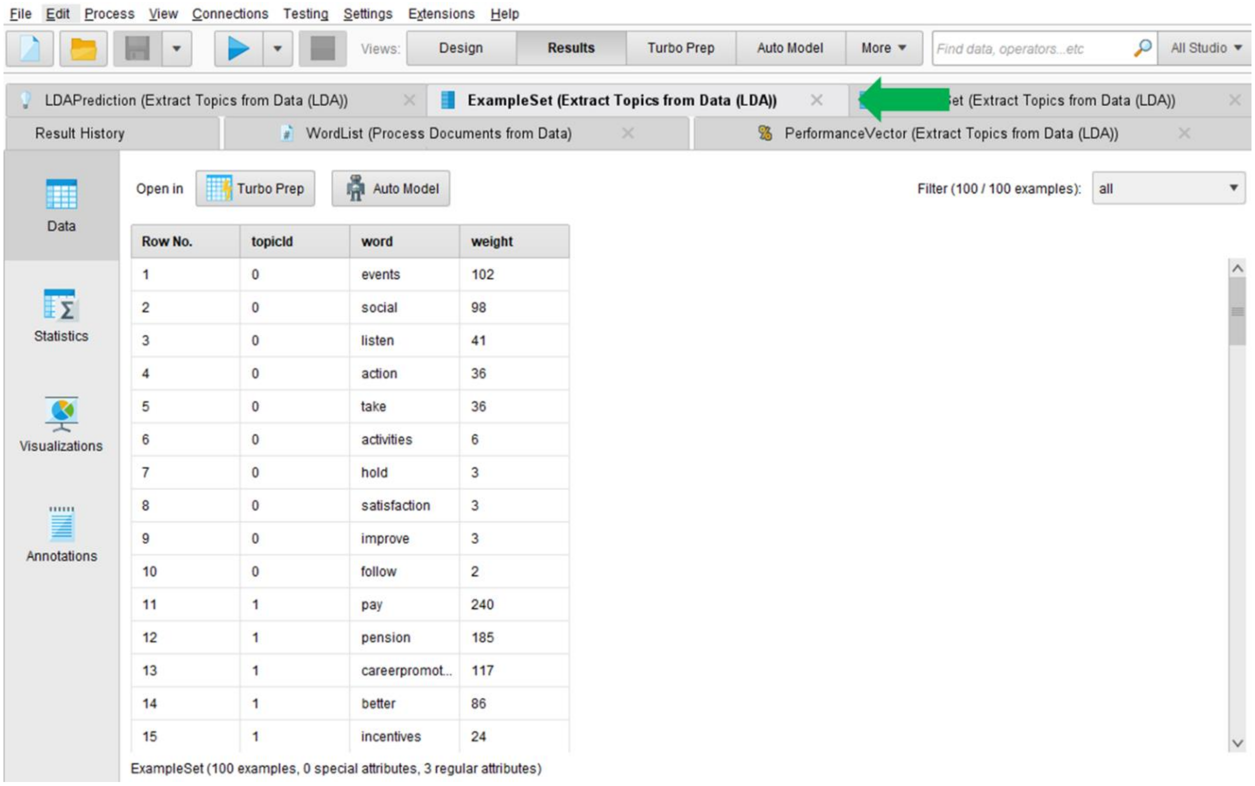
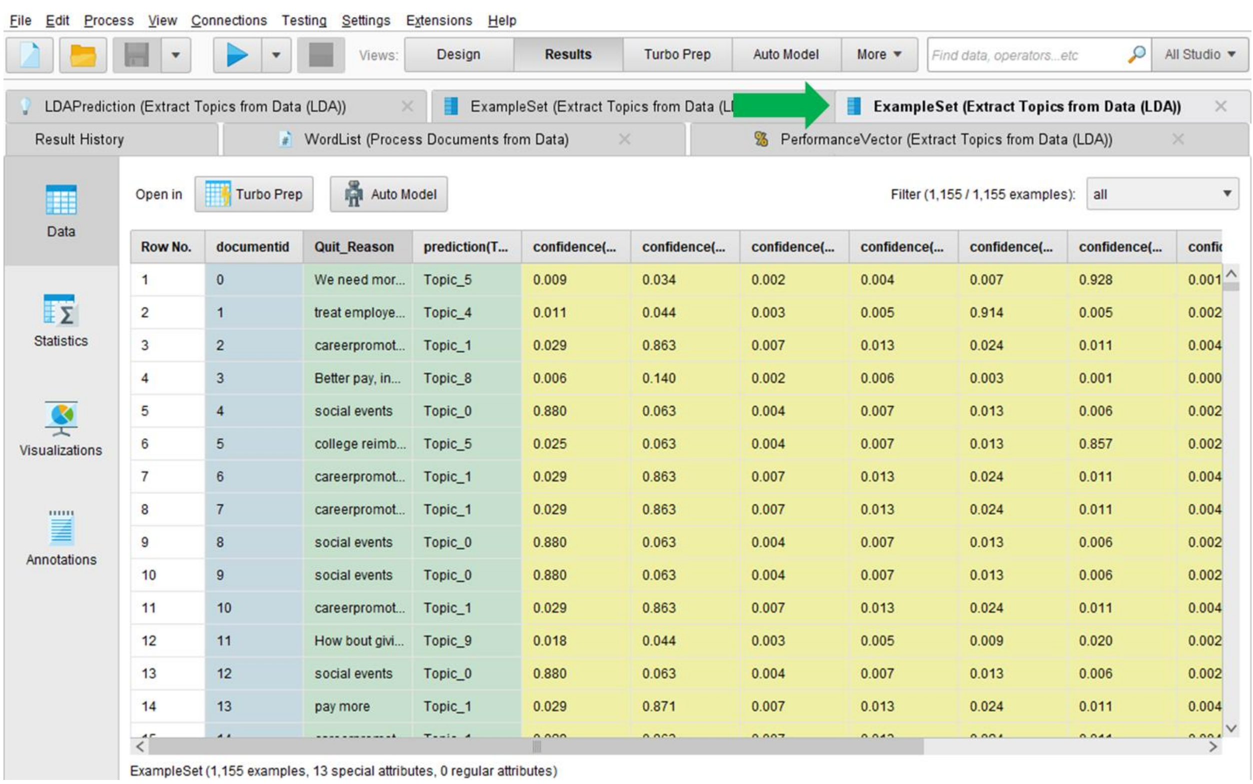


Figure 22. Process Results



Row No.	topicId	word	weight
1	0	events	102
2	0	social	98
3	0	listen	41
4	0	action	36
5	0	take	36
6	0	activities	6
7	0	hold	3
8	0	satisfaction	3
9	0	improve	3
10	0	follow	2
11	1	pay	240
12	1	pension	185
13	1	careerpromot...	117
14	1	better	86
15	1	incentives	24

Figure 23. ExampleSet (Extract Topics from Data (LDA))



Row No.	documentid	Quit_Reason	prediction(T...	confidence(...	confidence(...	confidence(...	confidence(...	confidence(...	confidence(...	confi
1	0	We need mor...	Topic_5	0.009	0.034	0.002	0.004	0.007	0.928	0.001
2	1	treat employe...	Topic_4	0.011	0.044	0.003	0.005	0.914	0.005	0.002
3	2	careerpromot...	Topic_1	0.029	0.863	0.007	0.013	0.024	0.011	0.004
4	3	Better pay, in...	Topic_8	0.006	0.140	0.002	0.006	0.003	0.001	0.000
5	4	social events	Topic_0	0.880	0.063	0.004	0.007	0.013	0.006	0.002
6	5	college reimb...	Topic_5	0.025	0.063	0.004	0.007	0.013	0.857	0.002
7	6	careerpromot...	Topic_1	0.029	0.863	0.007	0.013	0.024	0.011	0.004
8	7	careerpromot...	Topic_1	0.029	0.863	0.007	0.013	0.024	0.011	0.004
9	8	social events	Topic_0	0.880	0.063	0.004	0.007	0.013	0.006	0.002
10	9	social events	Topic_0	0.880	0.063	0.004	0.007	0.013	0.006	0.002
11	10	careerpromot...	Topic_1	0.029	0.863	0.007	0.013	0.024	0.011	0.004
12	11	How bout givi...	Topic_9	0.018	0.044	0.003	0.005	0.009	0.020	0.002
13	12	social events	Topic_0	0.880	0.063	0.004	0.007	0.013	0.006	0.002
14	13	pay more	Topic_1	0.029	0.871	0.007	0.013	0.024	0.011	0.004

Figure 24. ExampleSet (Extract Topics from Data (LDA))

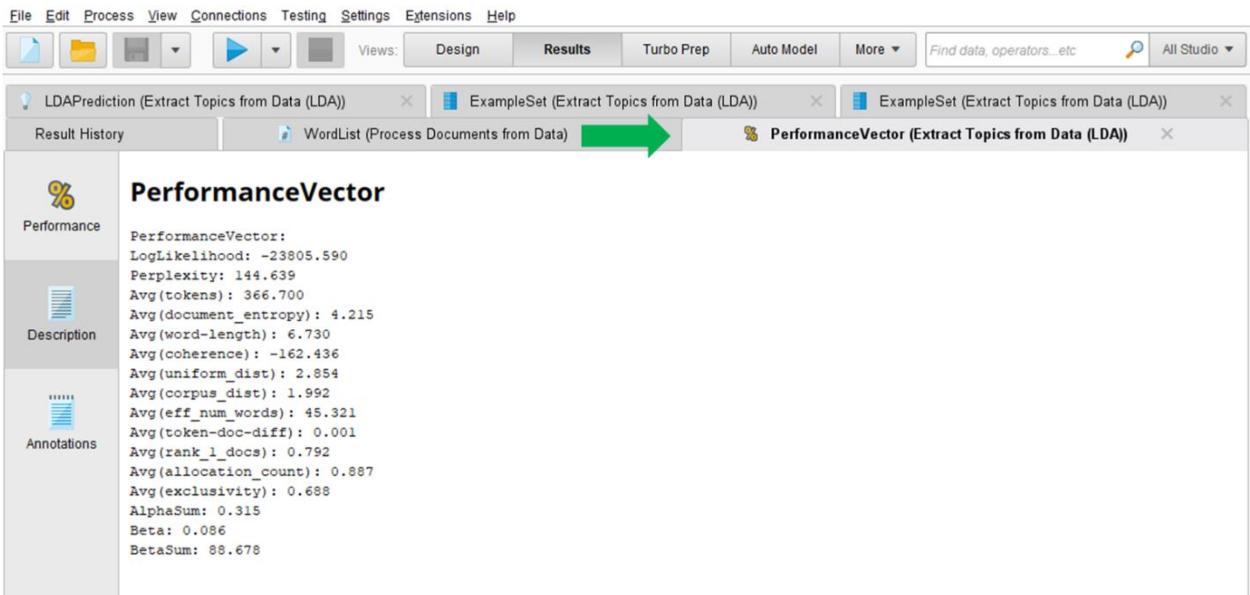


Figure 25. Performance Vector (Extract Topics from Data (LDA))

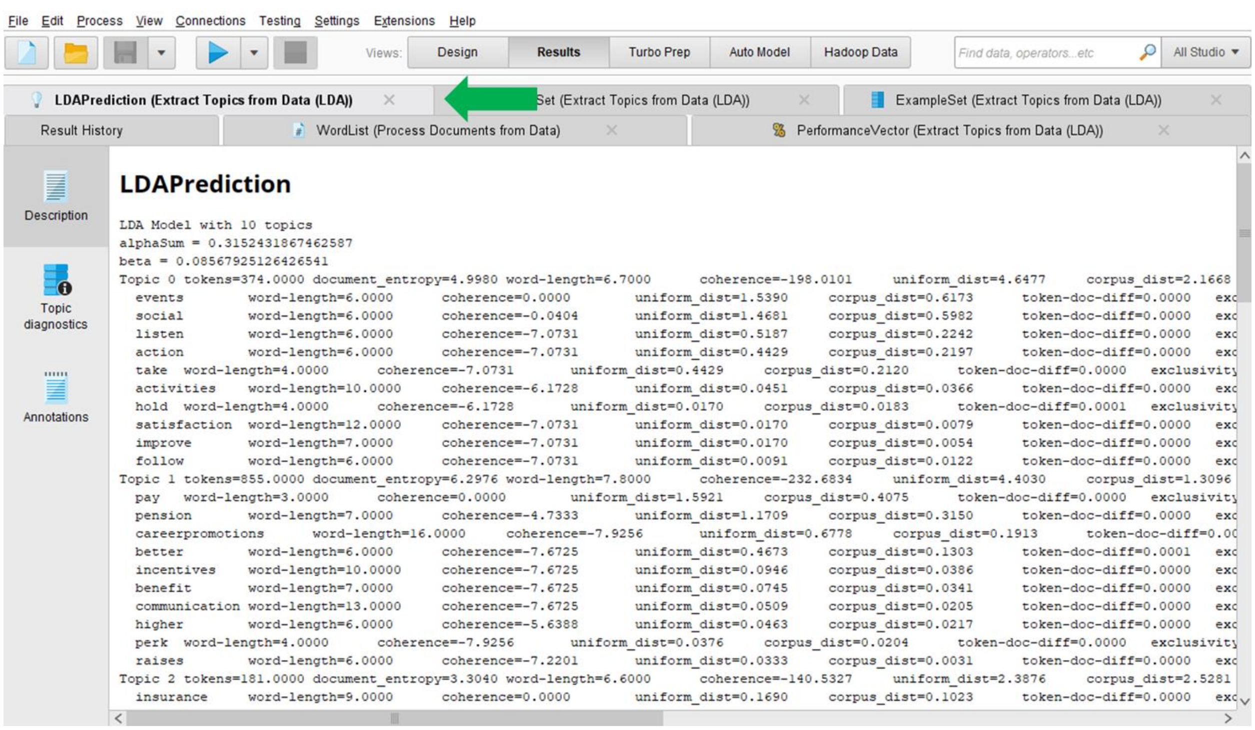
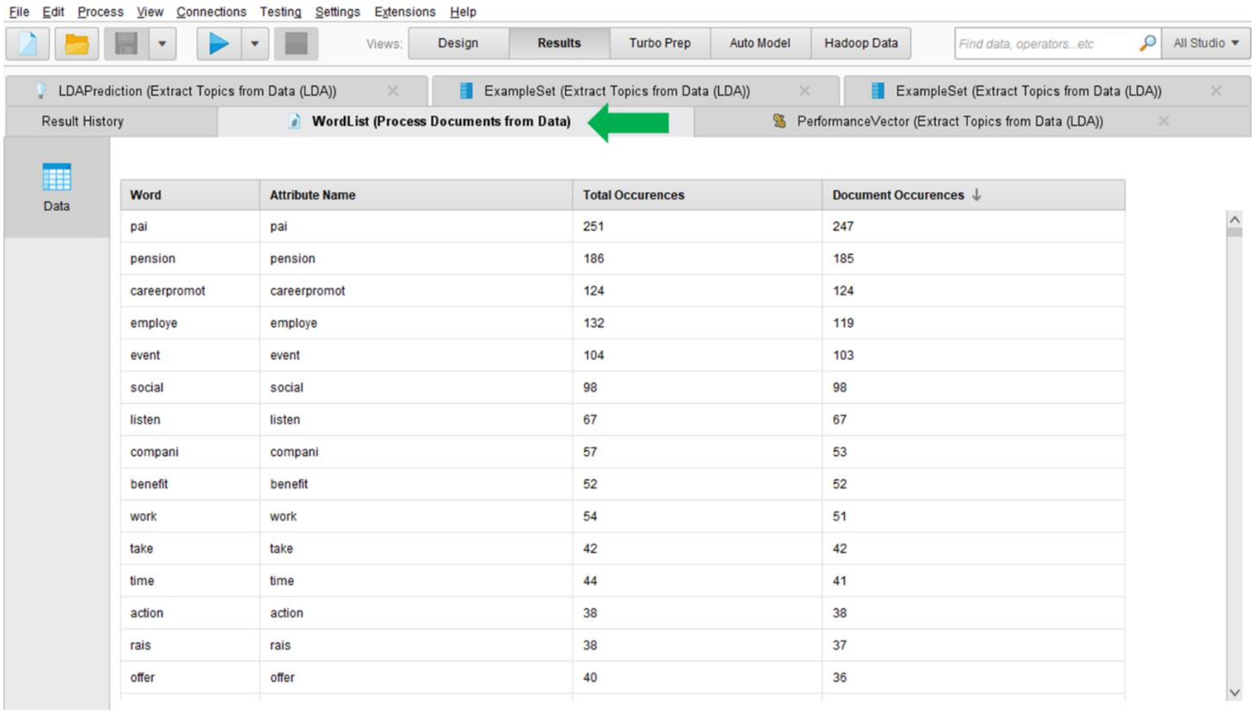


Figure 26. LDA Prediction (Extract Topics from Data (LDA))



Word	Attribute Name	Total Occurences	Document Occurences
pai	pai	251	247
pension	pension	186	185
careerpromot	careerpromot	124	124
employe	employe	132	119
event	event	104	103
social	social	98	98
listen	listen	67	67
compani	compani	57	53
benefit	benefit	52	52
work	work	54	51
take	take	42	42
time	time	44	41
action	action	38	38
rais	rais	38	37
offer	offer	40	36

Figure 27. WordList (Process Documents from Data)