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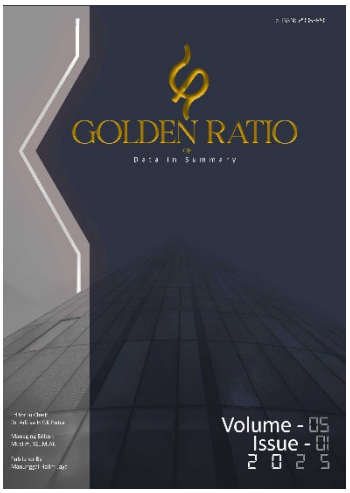

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DATA IN SUMMARY | ACCOUNTING, MANAGEMENT, BUSINESS, ECONOMIC

Implementation of Data Science in Economics and Business

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Abstract: Digital business transformation and the 5.0 era of the industry have made data science develop rapidly, and it is much needed to capture the potential of big data as a basis for business decision-making. How the Faculty of Economics and Business integrates data science into the curriculum will be challenging, considering that data science requires an understanding of mathematics, statistics, and technology. This research attempts to define data science and design the integration of data science into economics and business. Through the literature review process, it can be understood that data science is a multidisciplinary science (Mathematics, statistics, and other sciences according to their respective fields). Based on this, integrating data science into economics and business can be carried out by designing a curriculum that considers conceptual aspects of theory and the technical continuity of the use of technology.

Keywords: Data Science, Economics and Business, Scientific Integration.

1. INTRODUCTION

In the era of technological development and business digitalization. Data Science plays a vital role in utilizing data in all aspects of business and then analyzing it to generate information for decision-making in all business areas, such as R&D, manufacturing, marketing, operations, supply chain, customer relationship management, strategy formulation, finance, to human resources (van Tonder, Schachtebeck, Nieuwenhuizen, & Bossink, 2020). So, it is not an exaggeration to say that data science is a game changer in scientific exploration and innovation (Grossi et al., 2021). From the market side, the data science profession also received special attention as a talent needed in the era of the Industrial Revolution 4.0 by the World Economic Forum (WEF, 2019). In the report released in 2019, 85% of company CEOs want data science workers in their companies. Not only from the market side, the application of data science has also penetrated scientific writing in economics and business. This is reflected in the systematic literature review research (Nosratabadi et al., 2020). Various fields of business science, from human resource management to finance. It has been pretty much explored by this science, with different mathematical and statistical methods from naïve Bayes to genetic algorithms. The same thing also happens in Indonesia; it can be seen in several studies as follows (Suwandi, Xuan, & Nelson, 2023), (Dewi et al., 2023), (M. Harahap et al., 2022) which if you pay close attention, the research above is dominated by informatics engineering.

This condition stems from the complexity of data science, which is an intersection between Technology, Mathematics statistics, and Conceptual Knowledge of a particular field (Finzer, 2013). This complexity makes data science very dynamic to be studied with a specific scientific background, including socio-economic and business sciences. Like the two sides of a coin, data science, besides promising the positive side of its use, this science also has a steep side to explore and learn. Given that the technological side must also include a master's in data science, this side is the darkest area for

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someone outside of Informatics Engineering. A side that is fundamental to master or a way to understand the "LANGUAGE" used in the digital world. We need to understand the use of programming languages, syntax code writing, and technology tools, which are indeed something out of the ordinary for someone without an IT background. This condition often makes someone who wants to learn Data Science turn around because they are hindered by technical matters of 'LANGUAGE.'

Meanwhile, the needs of this profession continue to increase and need to be responded to by the curriculum of economics and business, which are in the social science family, as well as its relationship with informatics engineering in the exact science family, as a new drama in the face of digital era business disruption. This research tries to see the potential implementation of data science into business economics by conducting a literature review and providing a quantitative overview by looking at IT users' perspectives in the programming world. This research will provide insights for implementing the future data science curriculum into economics and business.

2. RESULT AND DISCUSSION

a. The Beginning of Data Science

The writing of Jhon initiated the emergence of data science itself. W Turkey, 'The Future of Data Analysis' written in 1962 (Bramwell, 2001) This means that more than mathematics and statistics are needed to handle data. Moreover, even in the continuation of the article, it is also emphasized that data analysis is not just computational science or computational science. (Tukey, 1972). In the article, Jhon. W Turkey answers various criticisms among statistics and mathematics academics. The change in the name of data analysis to Data Science was initiated through the Data Science Initiative (DSI) program conducted by the University of Michigan in September 2015 (Donoho, 2017) . Like its first appearance, the DSI program also received criticism from various academic circles. Data Science is considered only as a re-branding of statistical mathematics. It can be seen here that data science itself, from the beginning of its appearance, has indeed invited various controversies.

b. Definition of Data Science

The definition of data science, according to the Data Science Association, is the scientific study of the creation, validation, and transformation of data to create meaning. From this understanding, we can understand that data science is a science that includes stages: designing, validating, and transforming data aimed at producing useful information. Then what is meant by data here? Still, according to the Data Science Association, data is defined as a tangible or electronic record of raw (factual or non-factual) information (as measurements, statistics, or information in numerical form that can be digitally transmitted or processed) used as a basis for reasoning, discussion, or calculation and must be processed or analyzed to be meaningful. From these two conceptual understandings, we can understand that data science is the science of analyzing data (both digital data and data process) for helpful information. This understanding aligns with what Drew Conway describes in the data science Venn diagram.

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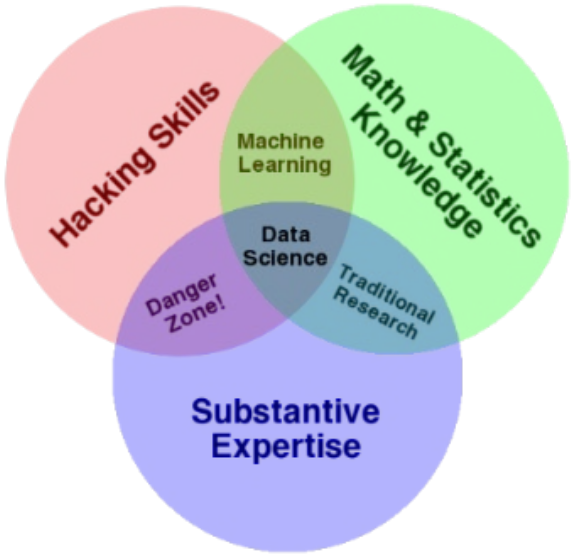

Figure 1. Data Science Venn Diagram

This diagram shows that data science is a multidisciplinary science involving computer science (programming), mathematics and statistics, and other scientific objects related to (Substantive Expert). So, it would become natural and commonplace for this science to be used in various scientific fields, including economics and business. Conway data science diagram updates can also be seen in the article. (Maslianko & Sielskyi, 2021).

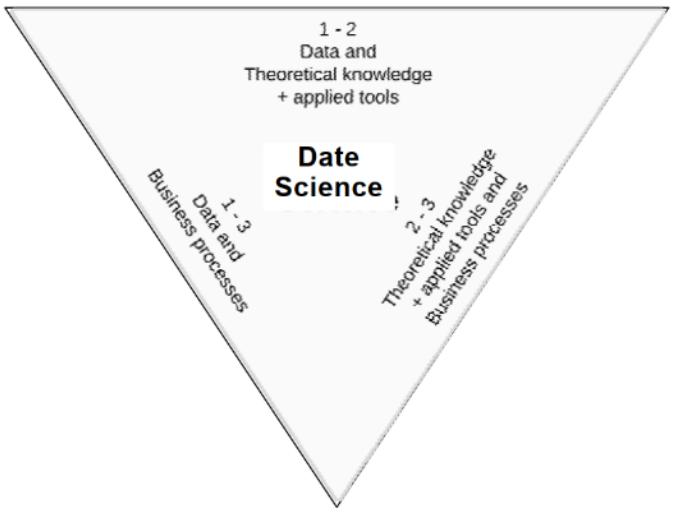

Figure 2. Data Science Venn Diagram Modified by Maslianko et al. 2021

Source : (Maslianko & Sielskyi, 2021)

Figure 2 shows that data science has developed into a technical (applied) and theoretical science in analyzing data on business processes, further emphasizing the need for interdisciplinary studies.

c. Data Science Skill Gap

The complexity of data science creates a gap between work practices and teaching curricula (Li et al., 2021). This problem arises because data science is a science that can only be fully obtained through multidisciplinary studies, and higher education institutions (universities) respond slowly to this. Dumbill, Liddy, Stanton, Mueller, & Farnham (2013), (Maddalena & Francesca, 2020). This condition is coupled with the challenge of teaching data science, which is still struggling only at the level of mathematics and statistics, not yet entering the use of computational programming and real

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data problems in the business world. (Finzer, 2013); (Stoudt et al., 2022). Indonesia itself has similar challenges. The curriculum development process for digital workers (data science included) is expected better to address the gap between curriculum and market needs (Gayatri et al., 2023).

d. Review of Data Science Curriculum Implementation

In the previous discussion, we know that by definition, data science is a science that is multidisciplinary (Interdisciplinary); this is also evidenced in the mission statement of several data science initiative forums created by several universities: Harvard Data Science Initiative, Novo Nordisk Data Science Initiative, North Western Data Science Initiative, Rice University Data Science Initiative. If you pay attention to the initiative forum, there is a similarity that there is always the word "multidisciplinary" or "interdisciplinary" collaboration. This also explains the similarity of the data science paradigm. A paradigm that this data science cannot stand alone requires a relational relationship to other scientific fields. Interestingly, data science practice in Indonesia is in different faculties. The Data Science Study Program is in the faculty of Mathematics and Natural Sciences (some of them IPB, Surabaya State University, Brawijaya University), the Data Science Study Program is in the faculty of Computer Science / Science and Technology (some of them; Veteran National Development University of East Java, Sumatra Institute of Technology, Parahyangan Catholic University, Open University). This, of course, more clearly illustrates that the scientific intersection of data science is indeed, by what is described in the Venn diagram of data science, drew Conway on the science of Informatics Engineering and Mathematics and Statistics. Then, in the substantive expert section, which requires multidisciplinary studies, Universitas Airlangga dares to be different in presenting a data science study program in the Faculty of Advanced Technology and Multidisciplinary. Seeing the development of data science, which is so dynamic practically and conceptually in its application in several faculties in Indonesia. The more interesting thing is whether Data Science can be applied to the faculty of economics and business. Given the substantive expert and data science modification framework proposed by Maslianko et al., l (Maslianko & Sielskyi, 2021) . In the following sections, this article will discuss the possibility of implementing Data Science in the Faculty of Economics and Business.

e. The Urge to Change Business in the Digital Age

Technological developments have significantly changed business from the industrial era 4.0 to 5.0. Technology has forced traditional business processes to be digitized and required innovation and speed of business decision-making (Henry et al., 2024) . This event makes the data science profession indispensable in the current condition. Call it some significant changes in the business process; in the field of marketing, for example, in analyzing market segments that were initially carried out traditionally with changes in business behavior patterns to digital and e-commerce experiencing demands for changes that are more quickly carried out and realtime, can be seen in several scientific studies as follows. (M. Harahap et al., 2022), (Rosihan et al, 2023).

The automation of financial analysis with programming languages makes the financial field undergo a crucial change, considering that decisions need to be taken in real-time (for example, in the analysis of stock purchase and sale decisions, for example) with the support of big data, this can happen. Several data science literature reviews have also discussed this, one of which is the book Python for Finance. (Hilpisch, 2014). The traditional financial analysis process, which used to take a long time to process and needed to be done repeatedly, became faster and automated.

Environmental and policy changes have also catalyzed the implementation of data science in business. The field of finance, which requires accounting science as the language of business as the basis for financial analysis, has experienced massive disruption. Regulations on the use of XBRL (Extensible Business Reporting Language) financial reporting standards on the IDX have made the accounting profession prepare itself. (K. Harahap et al., 2017).

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A little technical discussion about XBRL in programming: XBRL itself is an evolution of XML (Extensible Markup Language), a programming language that contains symbols that focus on storing and sending data between servers that can be done on a large scale and quickly. These symbols are usually numbers; accounting science revolves around numbers: nominal, account code, report year, transaction number, and others. This is the food for the development of digital technology (AI, Machine Learning, Data Automation) with the science of mathematics and statistics; these numerical symbols turn into scripts in machine learning, which makes the accounting profession need to experience development. Similar and clear things have also been revealed. A deeper description of data science techniques in analyzing accounting research can be seen. Based on the above conditions, if economics and business do not integrate data science, they will be in the Traditional Research area on the Conway data science Venn diagram, which will undoubtedly have an impact on the lagging adaptability of economics and business science in responding to the challenges of business changes in the digitalization era.

f. Challenges of Data Science Implementation in Economics and Business

The biggest challenge of implementing data science in economics and business is the technical use of technology. Looking at the modified data science diagram offered by (Maslianko & Sielskyi, 2021), applied tools are the biggest challenge in data science integration for people outside the IT background. The business process and theoretical business knowledge have naturally become challenging for economics and business science. However, is technology where the programming language in it is something that we cannot learn amid AI disruption today? and become a prohibition for an economist to understand Data Science? Let us look at the case study of the programming profession in learning technology in the data from the Stack Overflow Annual Developer Survey Questionnaire results in 2024, which amounted to 65,437 Developers worldwide. Stackoverflow is a website developers use worldwide as a reference for information technology. The website has been collecting questionnaire data from IT practitioners every year (from 2011 to the present).

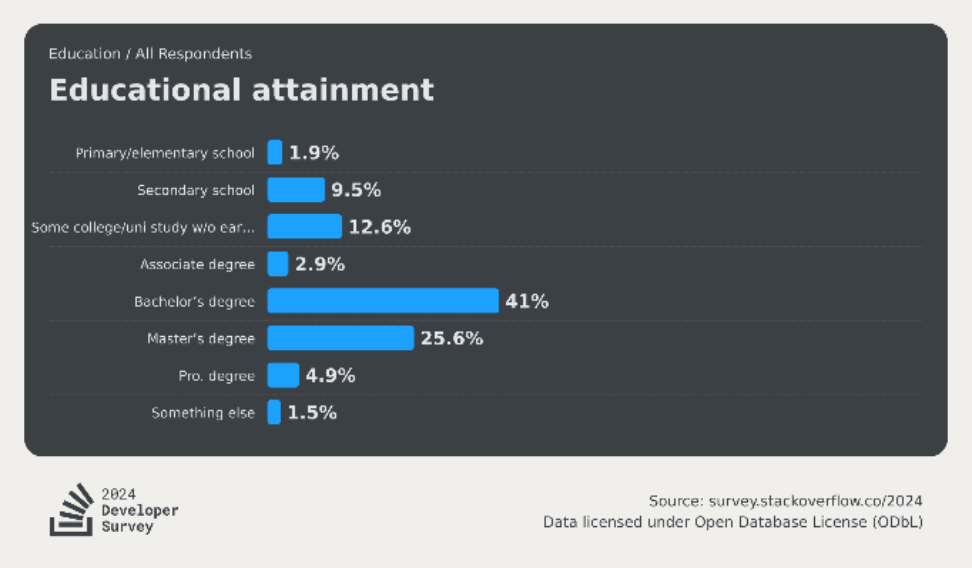

Figure 3. Educational Background
Source: Stack Overflow Developer Survey 2024

From the picture above, we know that various levels can learn digital skills in education with multiple disciplines (multidisciplinary). Moreover, the interesting thing is the statement:

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- 66% of developers have a BA/BS or MA/MS degree, despite only 49% of developers learning to code at school.
- 49% of respondents learned programming code in formal schools, and the remaining 51% knew it outside formal education. This indicates that many non-IT people can learn programming, including data science; this also opens the possibility of integrating data science into economics and business.

g. Benchmarking Data Science Integration into Economics and Business Science

Integrating data science into the Faculty of Economics and Business in practice has been carried out in several universities abroad: Plaksha University, Universitat Zurich, Lazarsky University, Nanyang Technological University, and University of Ljubljana. These universities, if seen from the curriculum, still have economic courses such as core microeconomics and macroeconomics. Even the University of Ljubljana is one of the institutions that has much influence in big data and data science articles based on bibliometrics analysis conducted by Ragazou et al., (2023).

h. Design of Data Science Integration into Economics and Business Curriculum

As a first step in this design, we must consider John W. Tukey's foundation in building data science. (Donoho, 2017), as follows:

a. The formal theories of statistics
b. Accelerating developments in computers and display devices
c. In many fields, the challenge is that more and ever larger bodies of data
d. are needed. Ta
e. There is an emphasis on quantification in an ever-wider variety of disciplines.

From this statement, we can understand that points no. 1 to 3 need to be done to answer the challenges of Big Data in the present, then point no. 4 is needed as a conceptual framework of knowledge in interpreting data and presenting helpful information, the same thing is also conveyed by Henry and Venkatraman (2015) in (Radovilsky et al, 2018). Significant data infrastructure comprises a big data repository, data analytics software, and data scientists. Data scientists use their knowledge and expertise in the growing field of data sciences, which requires strong mathematical, statistical, and information technology skills.

i. Technical Foundation

In the previous conceptual understanding, we have mentioned the words computers, display devices, and software, which, in this case, are related to technicalities. What is needed technically in learning data science, especially for people outside IT? To answer this, we can refer to the article. (Shamroukh & Johnson, 2023). In the article, Python was chosen as the programming language for non-IT people studying Data Science. Python was chosen because of the following reasons:

a. Python is considered a more straightforward programming language to learn than other programming languages.
b. Python is still quite dominant in today's programming languages, as we can see from the results of the 2024 Stackoverflow survey. Python ranks 3rd in terms of use as a programming language, as well as other programming languages.
c. As an open-source programming language, Python is supported by a community that builds various Python libraries. There are 562,967 libraries listed on pypi.org. This library makes it easier for us to do data science work;

    - Numpy, in performing numerical computations

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- Pandas (Python for Data Analysis)
- Matplotlib, in Data Visualization
- Scikit-Learn, in doing machine learning.

d. Material handbook support in the business process. To learn the use of Python in business analysis, we currently have many references in finance (Hilpisch, 2014), economics (Sargent & Stachurski, 2023), Big Data (Mitchell, 2018), and the use of statistics and machine learning (Kroese et al, 2019).

j. Integration Framework

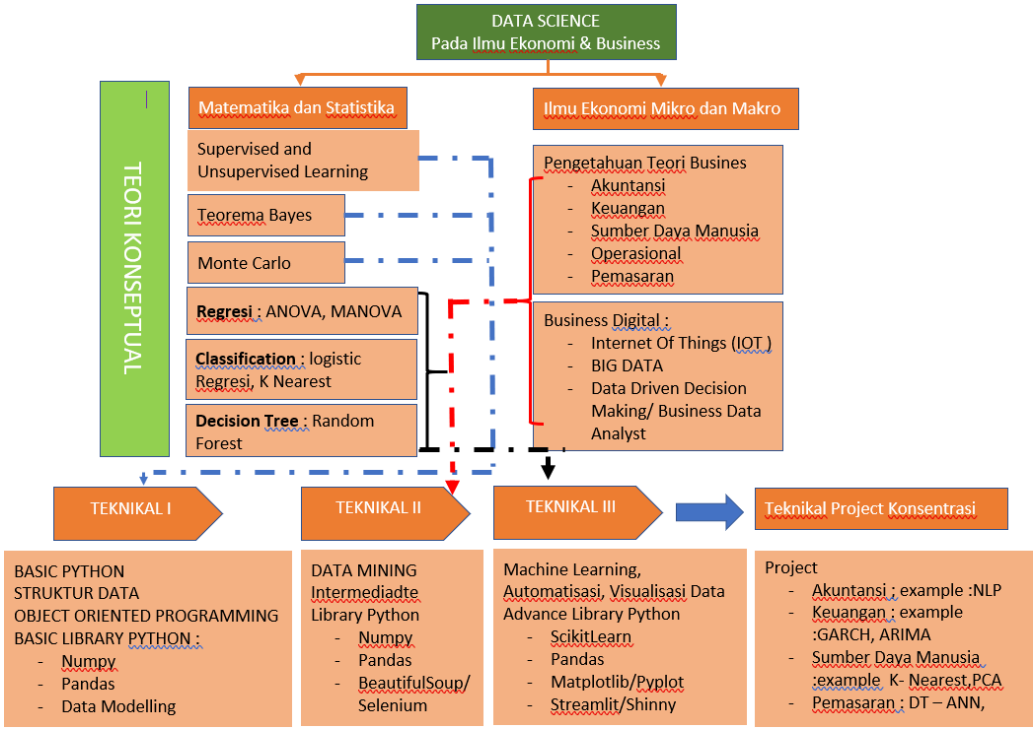

Figure 4. Integration framework

The integration framework proposed in this research tries to connect the conceptual theory of economics and business and the technical use of computing, which can be explained as follows: Conceptual Theory. As stated above, studying data science requires understanding theories from various disciplines (science). Data science will not run perfectly without being based on knowledge in their respective fields. (Donoho, 2017) . Therefore, instilling a conceptual understanding of the theory is the first step in learning data science. The conceptual theory that is to be proposed focuses on understanding science in the field of:

a. Math and Statistics. This understanding is necessary because data science will carry out a series of data processing processes and predictions, find patterns from data, and then make it into a data model. An understand
b. ing of functions in mathematics, optimization, and probability of data is essential to ensure the quality of the data model that is the output of data science.

As an important note, in the concept of mathematics and statistics in data science, it is necessary to understand the idea of Monte Carlo because this is a differentiator from mathematics and statistics without computing. With the help of computational science,

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modeling calculations with random factors can be done. The following is a brief description of the use of Monte Carlo: As an illustration in the calculation of home loans, with consideration of dynamic models of salary, promotion time, and investment return (fluctuating) using a data science data modeling process, we can do:

```
nilai_sensitivitas = {
    'gaji_awal': [i * 4000000 for i in range(12,25)], # Me
    'waktu_promosi': [i for i in range(3, 10)], # Membuat
    'tunjangan_hidup': [i/100 for i in range(3, 7)], # ske
    'tunjangan_promosi': [i/100 for i in range(2, 6, 11)],
    'simpanan_tapera': [0.03],
    'return_investasi': [i/100 for i in range(2, 7)], # Sk
    'harga_target_rumah': [340000000]
}
```

Figure 4. Example of Monte Carlo Usage

Syntax explanation:

By using Data science, we can experiment with various conditions. For example, in the syntax above, the promotion time variable is made for i in range, which means that we will simulate the calculation of salary increases for promotions that can occur every 3, 4, 5, and 10 years. Thus, the simulation model can explain the calculation of achieving housing targets under various conditions (Dynamic Model).

c. Economics and Business. This understanding has undoubtedly become the basis of economics and business. For example, in the syntax above (Figure 5) on the investment return variable, which is limited from 2 to 7, why is it only limited to 7? In economic science, we understand very well that, in practice, the achievement of standard investment returns rarely exceeds 8%, so we can create a simulation model close to the reality of practice in the business world.

As an essential note in the concept of economics and business, we need to understand the digital business transformation; this understanding will open the paradigm of "Big Data," which will further have implications for understanding Data Driven Decisions, which will explain why it is essential to do data mining in technical learning.

k. Technical

This technical section is divided into three stages of learning and one technical stage of making. This is done considering that the learning target of this data science curriculum is non-IT, which requires a gradual and continuous evaluation process.

a. Technical 1: This stage introduces the Python programming language, the libraries used in data science (including the installation process), and the relationship between mathematics and statistics in building simple data models.
b. Technical 2: We will answer the question of the relationship between Big Data and Business Digitalization at this stage. At this stage, data science learning will focus on searching, collecting, and cleaning data from the internet and websites.
c. Technical 3: Data science learning will focus on data visualization and automation. As well as applying machine learning as a link to theories found in mathematics and statistics.

Technical Project Concentration, at this stage, is a synthesis of business scientific theory and technical processes. This stage will test the reasoning and creativity of Data Science in solving business process problems.

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3. CONCLUSION

Data Science is a multidisciplinary science (Mathematics and Statistics, Computing, and science in their respective fields). Data science cannot run perfectly without scientific conceptual knowledge in each field. Based on this, the integration of Data Science into Economics and Business needs to be done, given the considerable disruption caused by digital business transformation that impacts the economic and business environment. The integration of data science into economics and business can be done by considering the following factors:

a. Conceptual understanding of mathematics, statistics, and business, and
b. Continuity of Technical computing skills. Technical computing is not something that non-IT people cannot learn. The development of available libraries, especially in Python programming, makes technical computing relatively more straightforward.

The results of this study are expected to bring new insights to higher education institutions, especially the faculty of economics and business, in responding to the challenges of technological developments in the business world. The literature review in this research is limited to understanding data science as a business analyst process, not touching on the data engineering process, where there are several understandings that data engineers are included in data science capabilities. So, the output of this research results in using Python as a data science tool, not entering using MySql as a tool. Further elaboration on data engineering and data science in business processes is a suggestion for future research. The integration framework proposed in this research is still general and does not yet detail the discussion of integration studies in each part, theoretically in mathematics, statistics, and business. Deepening the theory and examples of library use in these fields is needed as a suggestion for future research development.

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