Journal of Metaverse
Research Article
Received: 2023-05-25 | **Reviewing:** 2023-05-27 & 2023-09-07 | **Accepted:** 2023-09-08 | **Online:** 2023-09-13 | **Issue Date:** 2023-12-31
Year: 2023, **Volume:** 3, **Issue:**2, **Pages:**121-132, **Doi:** 10.57019/jmv.1302136

Learner-Centered Analysis in Educational Metaverse Environments: Exploring Value Exchange Systems through Natural Interaction and Text Mining

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***Abstract* – Amid Education 4.0 and the Fourth Industrial Revolution, we explore the integration of self-directed learning within the metaverse. This study envisions empowered learners, merging the metaverse's immersive potential with self-directed learning. Using text mining and co-occurrence analysis for student responses prompts questions about their preference over traditional methods. Text mining extracts nuanced insights from open-ended responses, surpassing structured data. Co-occurrence analysis reveals hidden concept relationships, enhancing student engagement and understanding. Beyond XR, the metaverse encompasses avatars, virtual experiences, and value systems. Educators navigate this landscape with text mining, shaping value exchange through engaging content. Integrating real-world experiences in the metaverse merges immersion and personalized learning. Challenges include data precision and semantic intricacies in co-occurrence graphs. Future solutions involve real-time adaptability and sentiment analysis for holistic insights into learner emotions. This study envisions a synergy of self- directed learning and the metaverse, bridging digital and physical realms. Learners navigate interconnected experiences, fostering autonomy. Uncovering the metaverse's potential contributes to education for digitally adept learners.**

***Keywords* – Education 4.0, learner-centered, educational metaverse, blockchain, value exchange, text-mining**

I. INTRODUCTION

The advancement of virtual reality (VR) and augmented reality (AR) technologies has created new opportunities for educational experiences [1]. One emerging concept in this field is the educational metaverse, which surpasses traditional VR representations and offers seven-layered environments that enhance learner-centered experiences and facilitate value exchange systems [2].

However, the metaverse goes beyond the simple transformation of the physical world into a digital realm [3]. Virtual reality (VR) and augmented reality (AR) technologies are tools rather than being synonymous with the metaverse. It embraces the opportunity to meet new needs and establish conventions distinct to the digital world. Looking back at human history, tools are initially perceived as natural and necessary creations. It is essential to recognize that tools have played a significant role in shaping and creating humans. Human intelligence has evolved through continuous trial and error in tool usage and the accumulation of their value. Dissatisfaction with existing tools has driven changes in the tools themselves and the workforce. Even in the face of tool loss or insufficiency, humans persistently seek advancements and contemplate improvements. The evolution of these innovations has been instrumental in the development and progress of human civilization.

The metaverse concept extends beyond 3D or extended reality (XR), AR, VR, and mixed reality (MR) technologies. It encompasses digital avatars and the representation of shared ecological value. However, it is essential to acknowledge the potential existence of a recoverable paradox within the metaverse. This paradox arises from the belief that combining the variability of the virtual world with the physical world can enhance the governing value of the metaverse. For instance, blockchain technology can revolutionize the credit system of universities, enabling the traceability of course values based on cryptocurrency.

This study conducts a learner-centered two-hour lecture course to challenge students' preconceived notions of an XR-dominated educational metaverse. Students actively under-stand and imagine the educational metaverse beyond XR concepts, emphasizing the value exchange system. Following the course, students are assigned to identify educational scenarios that cannot be realized within the metaverse. For a comprehensive analysis, their perceptions are collected through various materials, such as video recordings, written feedback, and audio files.

Text mining techniques are increasingly used to analyze and assess learning outcomes in educational settings [4]. Through text mining, it becomes evident that students recognize the limitations of XR-restricted academic cases and develop a profound understanding of the role of blockchain in the educational metaverse. They also grasp the significance of the development and definition of the seven-layer theorem in shaping a learner-centered educational metaverse.

This paper explores the potential of analyzing educational metaverse environments from a learner-centered perspective through natural interaction and text-mining techniques. Based on the feedback and confirmation from students, we have

Cite (APA): Tsai, Y. C. (2023). Learner-Centered Analysis in Educational Metaverse Environments: Exploring Value Exchange Systems through Natural Interaction and Text Mining. *Journal of Metaverse*. 3(2), 121-132. **Doi:** 10.57019/jmv.1302136

become more convinced of the critical influence of "value exchange" in an education-centered approach. This has reaffirmed three beliefs for us:

- Educational metaverse should not be confined to XR transformation alone without exploring the essence of value exchange. This has led to the misconception of prioritizing XR for the sake of XR, disregarding the true purpose.
- We should not negate the existence and necessity of the metaverse due to the disparities between virtual and physical realms. Instead, we should leverage value exchange to facilitate the transfer of value and amplify opportunities for value circulation through blockchain technology.
- The concept of an educational utopia can only exist if we are entirely self-sufficient and do not rely on any form of exchange to fulfill basic needs. However, even the slightest dependency on others creates a need for value exchange. The educational metaverse aims to assist learners in rediscovering their value position- ing, developing their worth, and being seen, utilized, and transferred. This process naturally leads them to identify the learning skills and knowledge they need to strengthen.

In conclusion, the educational metaverse seeks to empower learners to redefine their value and acquire the necessary skills and knowledge to enhance their worth. It recognizes the fundamental role of value exchange in the educational ecosystem, providing learners with opportunities to be identified, utilized, and have their value transferred. We can foster a more dynamic and effective educational environment by emphasizing value exchange.

This study explores the potential of self-directed learning in the metaverse, considering its implications for Education 4.0 and the Fourth Industrial Revolution. It emphasizes education's alignment with technology and learner-centered methods. The research delves into value exchange systems using natural interaction, text mining, and analysis. The metaverse transcends XR technologies, encompassing avatars and shared ecological value. Educators' role in adopting technology and text-mining for efficient learning is highlighted. The metaverse requires valuable content for user engagement. Integrating real-world experiences enhances its essence. This study unveils the metaverse's potential for learner-centered education in Education 4.0's context, aided by text mining analysis.

The subsequent section reviews learner-centered analysis, metaverse's value exchange, natural interaction, and text mining. Section 3 details the course design approach, emphasizing pedagogically meaningful activities. Section 4 discusses outcomes and feedback. Section 5 outlines limitations and suggests future directions. The paper concludes in Section 6.

II. LITERATURE REVIEW

The literature reviewed in this section highlights the relationship between Education 4.0 and learner-centered approaches, emphasizing integrating digital technologies and personalized learning experiences [5], [6]. Education 4.0 represents a paradigm shift in education, driven by rapid technological advancements, and aims to prepare learners for the Fourth Industrial Revolution [7]. Learner-centered approaches prioritize individual needs, interests, and goals, promoting active engagement and self-directed learning [8]. Integrating these two concepts is essential in designing effective educational environments [2].

Additionally, exploring learning outcomes through natural interaction and text-mining techniques offers new possibilities for assessing learners' progress and providing personalized feedback [4]. Natural interaction allows learners to interact with educational content using intuitive interfaces. At the same time, text mining enables the analysis of written responses and discussions [9]. Combining these techniques supports the development of adaptive learning systems and informs instructional design in a learner-centered Education 4.0 environment [10].

Furthermore, based on a value exchange system, the educational metaverse provides a platform for creating and exchanging valuable educational content and resources [11]. This aligns with the broader concept of the metaverse as a platform for value creation and exchange [12]. The educational metaverse offers interactive and immersive learning experiences, fostering more profound understanding, creativity, and learner collaboration [13].

Overall, the literature emphasizes the importance of learner-centered approaches, the integration of emerging technologies, and the value exchange system in shaping effective and engaging educational environments within the context of Education 4.0 [14].

The following subsections provide detailed insights into the relationship between Education 4.0 and learner-centered approaches, the use of natural interaction and text mining in assessing learning outcomes, and the concept of the educational metaverse based on a value exchange system [2], [3], [15].

A. *Relationship between Education 4.0 and Learner-Centered Approaches*

Education 4.0 signifies a profound paradigm shift in education, driven by the rapid pace of technological advancements and the imperative to equip learners for the challenges of the Fourth Industrial Revolution. This transformation is underpinned by a strategic emphasis on seamlessly integrating digital technologies, personalized learning experiences, and learner-centered pedagogies [16]. The intricate interplay between Education 4.0 and learner-centered approaches holds a central position within educational discourse, captivating considerable interest among scholars and researchers [17].

The contours of Education 4.0 encompass an array of emerging technologies, including artificial intelligence, virtual reality, augmented reality, and robust data analytics, each orchestrated to amplify and enrich the learning experience [18].

Conversely, learner-centered approaches pivot on an intrinsic dedication to address learners' individualistic needs, aspirations, and trajectories, propelling active engagement and fostering self-directed learning [19]. Fusing these two foundational concepts is an indispensable cornerstone in designing effective educational environments. By holistically intertwining Education 4.0's technological prowess with the tailored dynamics of learner-centered methodologies, educators are primed to nurture learners capable of absorbing and applying pertinent knowledge and skills within a digitally interconnected realm.

Empirical evidence accentuates that the deployment of learner-centered strategies within the realm of Education 4.0 yields marked enhancements in learning outcomes [20]. By positioning learners at the epicenter of the educational narrative, educators can intricately customize instruction, finely calibrated to match learners' distinct requisites, inclinations, and cognitive patterns. This approach engenders heightened engagement, motivation, and critical thought, concurrently deepening the fabric of comprehension woven around the subject matter.

The subsection encapsulates the dynamic interplay between these two pivotal pillars. Education 4.0's technological tapestry harmoniously converges with learner-centered paradigms, invigorating the educational narrative for learners navigating an era of profound digital transformation.

B. Exploring Learning Outcomes through Natural Interaction and Text Mining

Moreover, using natural interaction and text mining techniques in assessing learning outcomes has gained attention in recent years [21]. Natural interaction refers to intuitive and immersive interfaces allowing learners to interact with educational content using gestures, speech, or other natural modalities. Text mining, on the other hand, involves extracting valuable information from large volumes of text data, enabling researchers to analyze and evaluate learners' written responses, discussions, and reflections [22].

The combination of natural interaction and text mining offers new possibilities for assessing learning outcomes in a learner-centered Education 4.0 environment. By analyzing learners' interactions, responses, and textual data, educators can gain insights into their progress, strengths, and areas for improvement. This information can inform instructional design, provide personalized feedback, and support the development of adaptive learning systems that cater to individual learners' needs [23], [24].

C. Educational Metaverse based on Value Exchange System

The educational metaverse involves creating virtual and natural interactive learning environments where learners can interact with digital content, engage in simulations, and collaborate with others in a shared space. The value exchange system within this metaverse entails creating and exchanging valuable educational content and resources among learners, educators, and other stakeholders [2, 11].

The concept of the educational metaverse based on the value exchange system aligns with the broader idea of the metaverse as a platform for value creation and exchange. It emphasizes the importance of meaningful and valuable content in attracting and engaging users within the educational context. Learners can have more interactive and immersive learning experiences, allowing for a deeper understanding of complex concepts and fostering creativity and collaboration.

III. Methodology

The methodology employed in this study involved implementing a pedagogical strategy known as "book discussion. [25]" After attending a lecture on a specific topic delivered by the speaker, students are divided into groups and assigned a related theme for further discussion. One month later, students are tasked with critically examining and identifying the impractical aspects of the theories presented by the speaker through their group presentations. These presentations served as a platform for students to challenge the speaker's assumptions and hypotheses by providing evidence and counterarguments. Following the student presentations, the speaker had the opportunity to clarify any misconceptions that may have arisen during the lecture by addressing the points raised in the students' reports. Additionally, the speaker could reassess their assumptions based on the students' rebuttals and refine any aspects of their original hypotheses subject to criticism.

A. Research Subjects

The research subjects for this study were master students enrolled in a course specifically designed to explore emerging technologies and digital media. These students formed a diverse group with varying prior knowledge and understanding of the metaverse concept.

The students engaged in various learning activities throughout the course, including lectures, discussions, and hands-on projects. These activities were designed to introduce the meta- verse concept and facilitate the student's understanding shift from perceiving it solely as AR/VR/XR (Extended Reality) to recognizing it as a personalized learning system rooted in value exchange.

B. Research Tools

Text mining techniques were employed as the primary research tool to track and analyze the students' cognitive transition. The methodology involved collecting and analyzing textual data generated during the course, including written responses, discussions, and reflections.

At the beginning of the study, an initial survey was conducted to assess the students' preconceived notions and understanding of the metaverse. This served as a baseline for comparison throughout the research process.

Throughout the course, the students participated in book discussions, attended lectures, and engaged in interactive activities emphasizing the metaverse as a value-based learning environment. These activities encouraged critical thinking, collaborative learning, and the exploration of personal perspectives.

The student's written responses, discussions, and reflections were collected and subjected to text mining techniques, specifically natural language processing algorithms. These techniques enabled the researchers to identify patterns, track shifts in cognitive processes, and extract valuable insights from the textual data.

By analyzing the textual data using text mining techniques, the researchers gained a deeper understanding of the student's cognitive development and their evolving perceptions of the metaverse as a personalized learning system driven by value exchange. This analysis provided valuable insights into the student's mental journey and the factors influencing their conceptual shift regarding the metaverse.

C. Class Activity Design for Book Discussion

In this educational program, a total of 4 hours is allocated over one month. The first 2 hours are dedicated to the teacher providing a comprehensive introduction to the concept of the educational metaverse based on the value exchange system. During this time, students are encouraged to actively engage in the discussion, ask questions, and seek clarification.

1. Teacher to Students (2 hours): Following the initial 2- hour session, students are given 24 hours to reflect on the material covered and provide feedback. They are specif ically prompted to break down complex information into constituent parts and examine their relationships. This exercise encourages critical thinking and a deeper understanding of the topic.
2. Teacher and Students are together (1 month): Once the feedback is collected, the teacher organizes the students into teams for further exploration. The teams collaborate and discuss various scenarios to identify aspects that cannot be executed within the educational metaverse. This group activity fosters teamwork, critical analysis, and problem-solving skills.
3. Student to Teacher (125 mins): Over the next month, the teams work together to delve into their assigned topics, considering different perspectives and potential limitations. They engage in thorough discussions and reflections, drawing on the knowledge gained during the initial lecture and incorporating their feedback. The aim is to present their findings and thoughts at the end of the month, showcasing their collective insights and conclusions. Following the last 2-hour session, students are given 24 hours to reflect on the material covered and provide their feedback. Each team has 25 minutes for presentations and discussions. The following is a break- down of the time allocation for each team's activities:
   a) A Team Presentation (20 minutes): Bring the students together for a team presentation. Please encourage students to think critically and for- mulate their thoughts and opinions about the teacher's themes, characters, or plot. Pose ad- ditional thought-provoking questions to stimulate deeper analysis and critical thinking.
   b) Teacher's Reflection (5 minutes): The teacher sum- marizes the main points discussed after a team presentation. Teachers encourage students to reflect on their learning and insights from the teacher's main theory discussion.

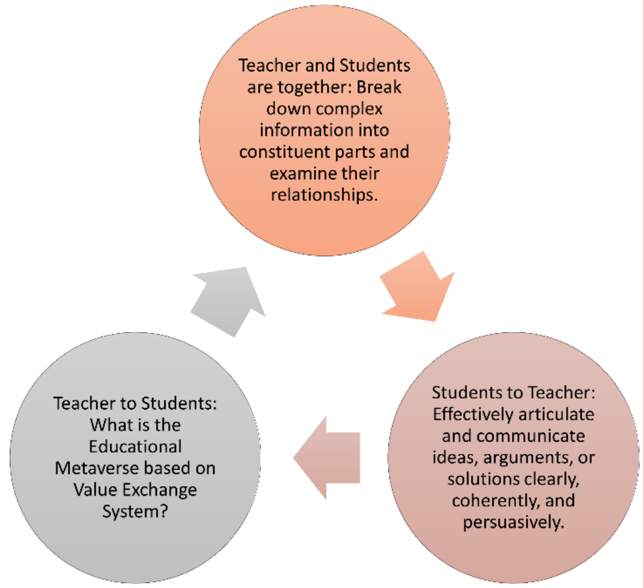


FIG. 1: The cycle of speculation in the critical thinking process emphasizes the active engagement of students in evaluating the teacher's proposition regarding an educational metaverse focused on value exchange systems.

There are a total of 24 master's students participating in this course. For the "Teacher and Students are together" task, the students are divided into five groups, and four groups comprise five members, while one group consists of four.

This structured approach gives students ample time to absorb the material, critically analyze it, engage in collaborative discussions, and present their reflections. By incorporating various stages of individual and group work, the program encourages active participation and comprehensive exploration of the educational metaverse based on the value exchange system.

In Fig. 1, the cycle of speculation in the critical thinking process emphasizes the active engagement of students in evaluating the teacher's proposition regarding an educational metaverse focused on value exchange systems. Notably, their efforts uncover the limitations present in the existing XR-based educational metaverse, as supported by the data they gather. This compelling evidence further strengthens the argument that the fundamental basis of an educational metaverse should revolve around the core concept of value exchange systems.

D. Extract Learning Outcomes from Verbatim Transcripts

Extracting learning outcomes from verbatim transcripts and utilizing text mining and co-occurrence analysis techniques provides a robust approach to deriving valuable insights from textual data. This methodology offers several advantages and requires considerations for assessing reliability and validity.

The collected verbatim transcripts, including written responses, discussions, and reflections, serve as the basis for the analysis. Text mining and co-occurrence analysis techniques identify the dataset's patterns, associations, and themes. The following categories and content descriptions were derived from the generated texts:

1. Teacher's Presentation: Transcriptions of the teacher's presentation on the educational metaverse and the value exchange system, encompassing explanations of the educational metaverse concept, introductions to the value exchange system, and insights on the potential of blockchain in education.
2. Students' Feedback: Students provided textual feedback regarding the educational metaverse and the value exchange system. This category includes positive comments, suggestions for improvement, reflections on the discussions, and opinions on the limitations of the XR- based educational metaverse.
3. Group Discussions and Students' Reflections: Written reflections provided by students after a month, summarizing their thoughts and key takeaways from the course. The content encompasses reflections on the importance of value exchange in education, insights gained from group discussions, an understanding of the seven-layer theorem in the educational metaverse, ideas for enhancing the value exchange system, identification of educational scenarios that cannot be realized, and proposals to overcome limitations.
4. Analysis and Insights: Textual analysis of the collected data to identify patterns, trends, and insights related to the educational metaverse and the value exchange system. This category includes the identification of common limitations in the XR-based educational metaverse, understanding the role of blockchain in enhancing the credit system, and exploring the learner-centered aspects of the educational metaverse.

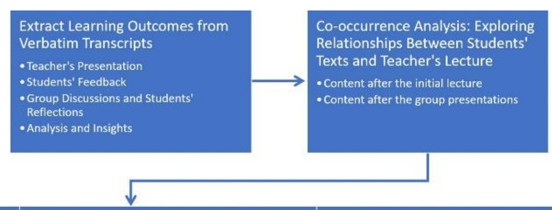
To ensure the reliability and validity of the findings, it is important to address the following:

- Reliability: Assess the consistency and stability of the automated text mining and co-occurrence analysis. Consider test-retest reliability by analyzing a subset of the data at different time points and evaluate inter-rater agreement if multiple researchers are involved.
- Validity: Ensure the content validity of the analysis by selecting appropriate keywords, phrases, or patterns that accurately capture the relevant concepts. Consider criterion validity by comparing the results with established measures or expert judgments. Additionally, assess construct validity by aligning the identified patterns and associations with relevant theoretical frameworks and concepts.

Despite the need for reliability and validity assessments, text mining and co-occurrence analysis offer valuable benefits for extracting learning outcomes:

- Efficient and Scalable Analysis: These techniques allow for efficiently processing large volumes of textual data, enabling the extraction of insights from extensive datasets.
- Unbiased Exploration: Automated analysis techniques minimize researcher bias, facilitating the discovery of unexpected patterns and relationships within the data.
- Pattern Detection: Text mining and co-occurrence analysis reveal underlying connections and associations by examining the co-occurrence of terms and patterns, providing a comprehensive view of the educational metaverse and the value exchange system.
- Hypothesis Generation: These methods can generate hypotheses and research questions for further investigation, contributing to the development of future studies and guiding research directions.

By incorporating text mining and co-occurrence analysis, this research approach enhances the understanding of learning outcomes within the context of the educational metaverse and the value exchange system, ultimately contributing to advancing knowledge in this field.



	Content after the initial lecture	Content after the group presentations
Student 1	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...
Student 2	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...
...	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...
Student 24	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...	Students' feedback after receiving feedback from the teacher ... Word1, Word2, Word3, ...

FIG. 2: The Segmentation of Students' Texts and Teacher's Lecture.

E. Co-occurrence Analysis: Exploring Relationships Between Students' Texts and Teacher's Lecture

A text-mining approach has been designed to segment students' feedback into two categories to analyze these different types of texts and transcriptions. The first category includes the content provided immediately after the initial lecture, capturing their initial impressions and understanding. The second category comprises the content generated after the group presentations, including their reflections and responses to the feedback provided by the teacher. Figure 2 is the segmentation of the texts, and the following are the specific segments:

1. Content after the initial lecture: This segment in- cludes students' initial responses and impressions of the teacher's

lecture and their understanding and perspectives on the importance of value exchange in education.

2. Content after the group presentations: This segment comprises students' observations and reflections following the group discussions and presentations. They can share new insights, perspectives, and experiences gained during the discussions.

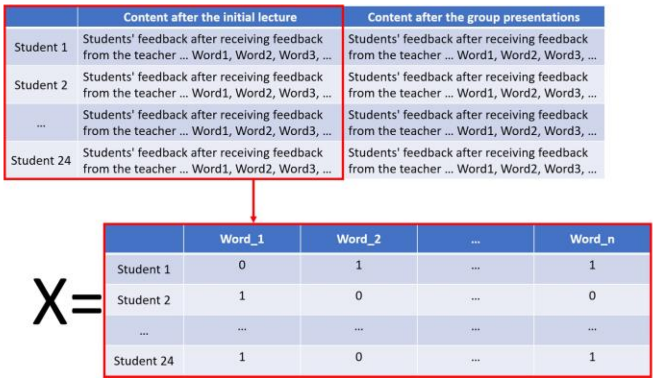


FIG. 3: To create a term-to-document matrix by segmenting students' texts and the teacher's lecture.

By categorizing the text into different categories and performing term extraction, you can create a term-to-document matrix, denoted as X (see Figure 3), where each row represents a student, and each column represents a word extracted from the student's transcriptions. The entries in the matrix represent the frequency or presence of each word in each student's text. To generate co-occurrence matrices [26], we can use two different approaches:

1. Word Co-occurrence Matrix (X⊤X): Transposing the term-to-document matrix X, we obtain X⊤, where each row represents a document, and each column represents a term. Multiplying X⊤ with X yields the term co-occurrence matrix, where each entry represents the number of times two terms co-occur within the same document. This matrix captures the co-occurrence patterns of terms in one of the datasets.

2. Student Co-occurrence Matrix (XX⊤): Multiplying X with its transpose X⊤ generates the student co- occurrence matrix, where each entry represents the number of terms that two students share in common. This matrix captures the similarity or overlap in the understanding characteristics among the students.

When we have two categories, such as students' initial feedback and group presentations and feedback, and each type can generate two co-occurrence matrices, we will ultimately obtain four co-occurrence graphs for analysis. The four co-occurrence graphs represent the relationships and patterns of co-occurrence between words or phrases within each category. By analyzing these graphs, we can gain insights into the connections and associations between terms or concepts within the students' feedback and their interactions with the teacher's lecture text.

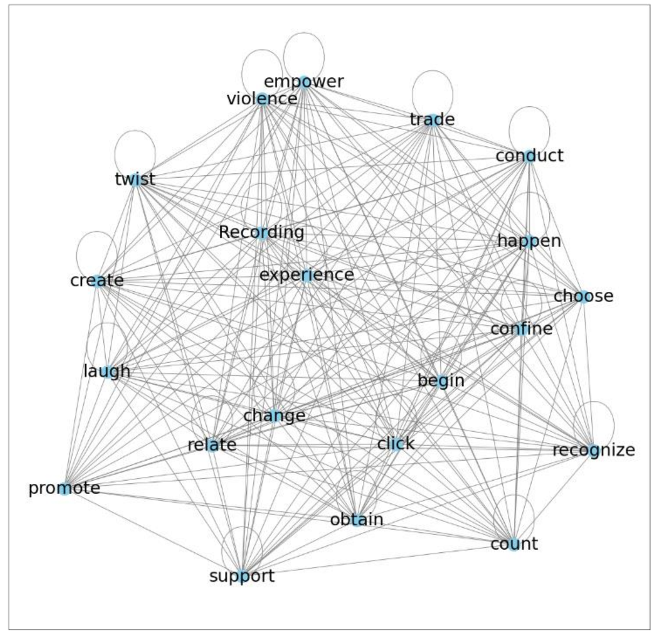


FIG. 4: A co-occurrence graph from the Word Co-occurrence Matrix.

For example, Figure 4 depicts a co-occurrence graph derived from a word co-occurrence matrix. This graph visualizes the relationships between words by representing them as nodes and using edges to indicate their co-occurrence patterns. Let's consider a corpus of news articles about technology. In the co-occurrence graph, each word corresponds to a node, and the connections between nodes represent the frequency or occurrence of these words appearing together in the text. Words that frequently occur together will have strong connections, while words that rarely co-occur will have weaker or no connections. By examining the co-occurrence graph, we can observe which words frequently appear together in the text and identify clusters or groups of related terms. For instance, words like "technology," "innovation," and "digital" may form a closely connected cluster, indicating their thematic relevance. On the other hand, words like "technology" and "nature" may have weaker connections, suggesting less frequent co-occurrence and potentially indicating contrasting concepts.

Analyzing the structure of the co-occurrence graph can help researchers understand the semantic relationships between words and uncover underlying themes or topics within the text. This information can be helpful for task modeling, retrieval, or text summarization.

In summary, co-occurrence graphs visually represent word relationships in a text and offer insights into the clustering, association, or thematic relevance between words. By examining these graphs, researchers can gain a deeper understanding of the structure and content of textual data.

IV. RESULTS

The steps for conducting a co-occurrence analysis between students' reflections and the teacher's perspective are as follows:

1. Data preprocessing: Convert the students' reflection data into a suitable tokenization format, remove stopwords, and define keywords.
2. Feature extraction: Transform the preprocessed words into a document-to-term matrix, which serves as the basis for feature vectors representing students' views on specific terms.
3. Build a co-occurrence matrix:
   a) Build a word co-occurrence matrix: Use the extracted feature vectors to construct a co-occurrence matrix, where each element represents the number of times two features appear together in the same student text.
   b) Build a student co-occurrence matrix: Utilize the extracted feature vectors to establish a co-occurrence matrix. Each element represents the number of times two members occur together using a specific term.
4. Construct co-occurrence networks: Based on the co-occurrence matrices from steps 3(a) and 3(b), create separate co-occurrence networks for word and student perspectives, where nodes represent features and edges represent co-occurrence relationships.

Visualization and analysis: Visualize the co-occurrence networks and community structures using graph theory, enabling further analysis of patterns and trends in students' reflection changes.

FIG. 5: The steps for conducting a co-occurrence analysis between students' reflections and the teacher's perspective.

Figure 5 illustrates the application of the analysis above steps, enabling a comprehensive understanding of the significant themes present in students' reflections during two instances, the interrelationships between these themes, and the changes observed over time. This analysis provides valuable insights into students' learning processes and their values and beliefs shifts.

Each co-occurrence graph visualizes the frequency and strength of co-occurrence between terms. Nodes in the graph represent individual terms, and the edges between nodes indicate co-occurrence relationships. The thickness or intensity of the edges reflects the strength of the co-occurrence. By examining the co-occurrence graphs, we can identify clusters or groups of related terms within each category. These clusters represent common themes, concepts, or ideas appearing in texts. Analyzing the structure and patterns of the graphs helps us understand the interrelationships and recurring topics within the students' feedback and their connection to the teacher's lecture. Analyzing these four co-occurrence graphs provides a total value of the links and associations in the students' feedback, highlighting the shared understanding, key concepts, and focus areas within each category. It assists in uncovering patterns, trends, and the overall coherence of the discussions and reflections related to the educational content.

Analyzing these co-occurrence matrices can provide insights into the co-occurrence patterns of words and the shared understanding characteristics among students. Researchers can apply techniques such as clustering, network analysis, or dimensionality reduction to explore the relationships and patterns within the matrices, thereby gaining a deeper understanding of students' learning outcomes and collective understanding.

Co-occurrence analysis is a powerful text technique that allows us to delve into the relationships between the texts of the 24 students and the teacher's lecture. By identifying co-occurring patterns, we can uncover associations and connections within the texts, shedding light on the student's level of understanding and engagement. In this analysis, we preprocess the texts by removing stop words and punctuation, ensuring that the data is in a suitable format for examination. Subsequently, we construct a co-occurrence matrix, which captures the frequency of words appearing together in the students' texts and value teacher's lecture. The co-occurrence matrix serves as the foundation for our exploration. Examining the patterns within this matrix allows us to discern words or phrases that frequently co-occur in the texts. Such co-occurrences offer insights into the students' incorporation of ideas from the teacher's lecture into their reflections. If particular terms or concepts consistently appear together, it indicates the students' firm grasp and assimilation of those ideas. This analysis also enables us to identify key themes or topics that emerge across the texts, highlighting areas of shared understanding, agreement, or divergence between the students and the teacher. By comprehensively studying the co-occurrence patterns, we gain valuable insights into the level of engagement, comprehension, and assimilation of the lecture content among the students.

Figure 6 illustrates that the co-occurrence graph reveals three central nodes: "Us (我們)," "Metaverse (元宇宙)," and "Value (價值)." The links originating from these major nodes demonstrate their dynamic interactions and relationships. Regarding "Us," we connect with the meta value by embracing Education 4.0, which harnesses cutting-edge educational technologies and digitalization to elevate the quality of learning and teaching experiences. Moreover, we engage with Value through the Education Metaverse, integrating values and ethical end-social responsibility principles into the learning journey. In this interaction, the Education Metaverse is seen as an ecosystem of value exchange, utilizing blockchain and digital tokens to verify and store learners' Value. This value exchange system allows learners to gain recognition and rewards through participation and contributions, actively engaging in the value circle. The interaction of the Education Metaverse has significant implications for the behaviors and meanings within the value circle. Through educational approaches and interactions among learners, they can explore and practice behaviors and definitions related to values, ethics, and social responsibility in the virtual world. The Education Metaverse provides a new learning environment where learners can experience and apply these value concepts and interact and collaborate with other learners. This article emphasizes the importance of Education Metaverse, Education 4.0, and value exchange. These concepts form an interactive system that promotes learners' value creation and growth. Additionally, the article reminds us to reflect and conduct further research on Education Metaverse while addressing potential challenges and issues.

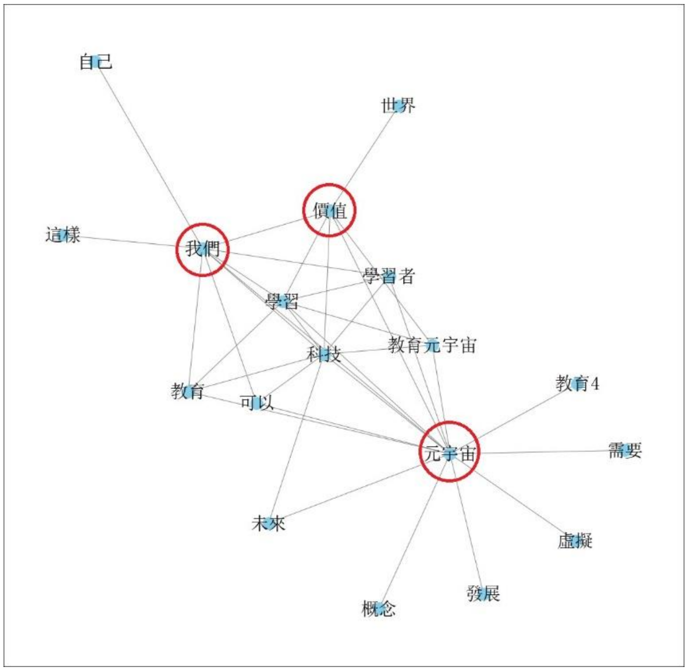


FIG. 6: Word Co-occurrence Graph from the Content after the Initial Lecture.

Figure 7 illustrates a co-occurrence graph in which four central nodes are identified: "Metaverse (元宇宙)," "Us (我們)," "Value (價值)," and "Experience (體驗)." The Metaverse establishes a connection with Us through blockchain technology, facilitating various activities and interactions within the metaverse. Blockchain technology achieves this through data verification, storage, and transmission. The metaverse intersects with "Value" through creation, transfer, and environment. Within the metaverse, individuals can create and experience different values and cultures that can be shared and communicated. "Value" is linked to Experience through education and content. Education and content play crucial roles in the metaverse, providing learning opportunities and serving as carriers and conveyors of values. These interconnected elements form a value exchange system where Experience is critical. Through participation and experiences, we receive recognition and rewards for the "Value" we contribute while contributing our experiences and importance to the metaverse. Ultimately, this system completes a loop as experiences return to the blockchain, where our actions and deals are verified and stored. This loop allows us to continually participate, create, and exchange value within the metaverse. The co-occurrence graph illustrates the relationships and interactions among the "Metaverse," "Us," "Value," and "Experience." This system facilitates value creation, sharing, and exchange while offering diverse learning and experiential opportunities.

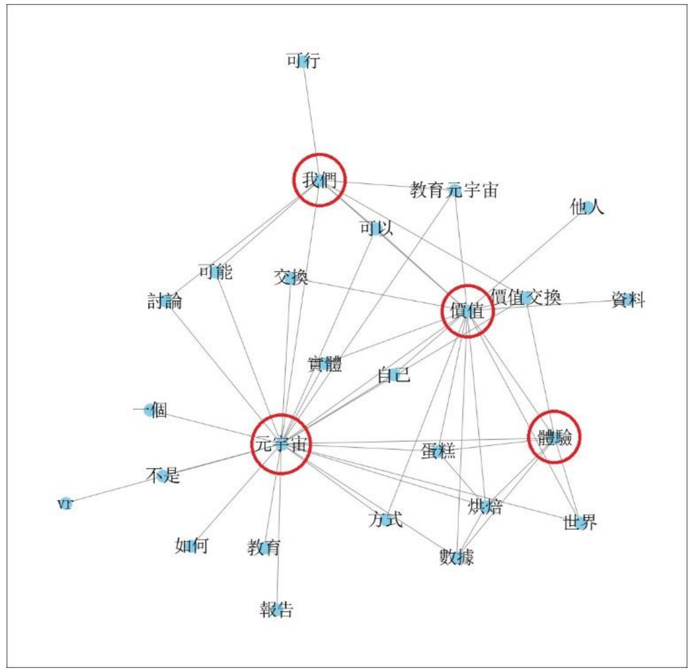


FIG. 7: Word Co-occurrence Graph from the Content after the Group Presentations.

The difference between Figure 6 and Figure 7 lies in their focus on the central nodes and their interconnections. The first paragraph describes a co-occurrence graph with major nodes of "Us," "Metaverse," and "Value," emphasizing the role of Education 4.0 and the Education Metaverse. It highlights the value creation and growth students achieve through integrating these concepts. On the other hand, the second paragraph introduces "Experience" as an additional central node in the co-occurrence graph and emphasizes its relationship with value. Based on these differences, it can be inferred that the students who wrote these texts have undergone some cognitive changes. They may have started to realize the crucial role of Experience in the Education Metaverse and its interconnectedness with value. This shift in awareness might lead them to value practical experiences in the learning process and consider them integral to value creation and exchange. Additionally, they might contemplate how values can be conveyed and shared through education and content, recognizing the potential for practicing and applying these values in virtual environments. In writing these texts, these students have undergone a cognitive change in their understanding of the Education Metaverse, Education 4.0, and value exchange. They have become aware of the importance of Experience in value creation and exchange and have started contemplating how to embody these values within virtual learning environments. These cognitive changes reflect their deeper reflection and understanding of education and learning.

Figure 8 shows that 0 is the teacher and 1–24 are the students' IDs. The student co-occurrence graph is from the content after the initial lecture. In Table I, although the viewpoints of students 2 and 7 have lower co-occurrence with the teacher, careful examination of their descriptions reveals exciting insights. Student 2 emphasizes the curiosity sparked by understanding the teacher's life story, the pursuit of being valued, and self-directed and collaborative learning trends. On the other hand, student 7, in their conversation with the teacher, expresses a contradiction regarding the different statuses of education in the past and present society. They believe that learning should be connected to life experiences and that students should be the drivers of their knowledge. The emergence of the educational metaverse empowers teachers to serve as facilitators, enabling equal communication and fostering a deep understanding of the meaning and value of learning for students. The article also highlights the importance of student-centered teaching approaches, leveraging technology and innovative methods. Educators should guide students to develop the necessary skills to face future challenges. The above observations highlight the nuanced perspectives of students, further emphasizing the relevance of the value exchange system in the educational metaverse.

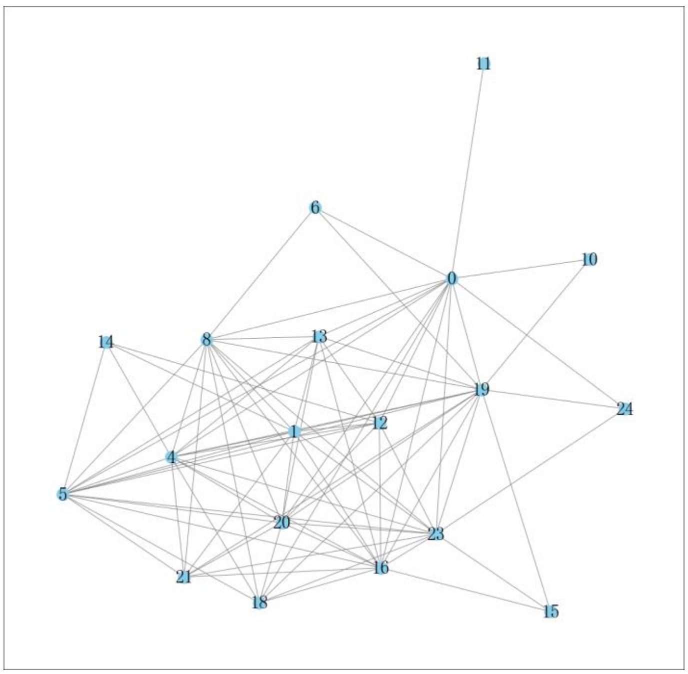


FIG. 8: Student Co-occurrence Graph from the Content after the Initial Lecture.

Figure 9 shows that 0 is the teacher and 1–24 are the students' IDs. The student co-occurrence graph is from the content after the group presentations. Table I shows that the co-occurrence between students and the teacher's perspectives has significantly strengthened in the second round of feedback. All students' views now demonstrate a high degree of alignment with the teacher's viewpoint. This indicates that students clearly understand and can articulate the discourse surrounding an educational metaverse centered around a value exchange system. They can depict a narrative that closely aligns with the teacher's perspective. This suggests that students have embraced the concept of an educational metaverse where the value exchange system plays a central role. They have internalized its principles and can articulate their thoughts in a manner consistent with the teacher's discourse.

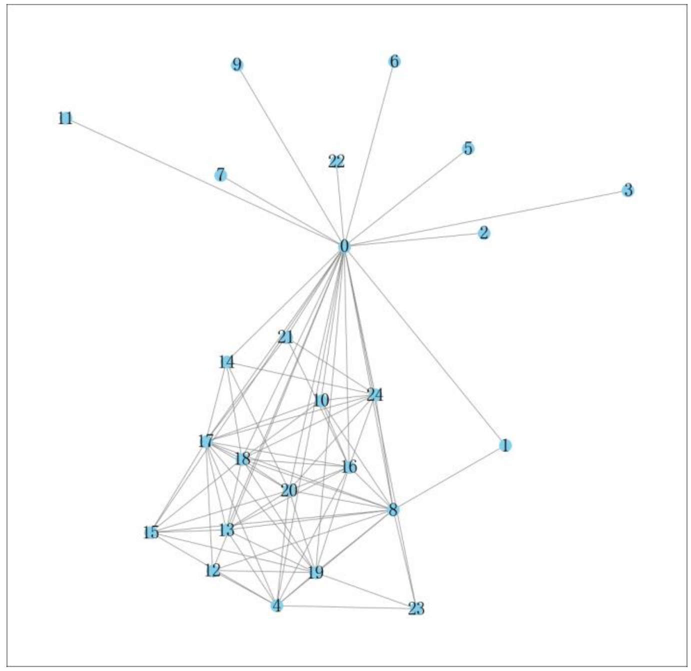


Fig. 9: Student Co-occurrence Graph from the Content after the Group Presentations.

TABLE I: The table shows the co-occurrence weights between students and teachers in the student co-occurrence matrix for two segmentation scenarios. The first two columns correspond to the weights after the initial lecture, and the last two columns correspond to the weights after the group presentations.

Stu. IDs	Weight in Fig. 8	Stu. IDs	Weight in Fig. 9
19	506	8	1128
20	359	4	818
16	348	19	801
23	343	15	707
5	322	20	687
4	312	17	575
8	300	12	562
18	228	23	553
13	205	18	536
11	192	13	526
24	178	16	500
6	178	24	446
12	163	11	442
10	151	3	427
17	140	1	412
15	139	9	344
14	137	10	334
1	127	6	331
21	123	14	308
9	93	5	282
22	87	2	249
3	78	7	247
2	64	21	230
7	38	22	208

V. Discussion

In the study, the responses provided by students were analyzed using text mining and co-occurrence analysis techniques. The choice of these methods over traditional measures like written exams, questionnaires, or statistical comparisons raises the question of why such an approach was preferred. The rationale behind this preference lies in the ability of text mining and co-occurrence analysis to capture nuanced and context-rich information from open-ended responses. Unlike traditional methods that may provide structured but limited insights, text mining allows for identifying patterns, themes, and relationships within the textual data. Additionally, co-occurrence analysis helps unveil connections between concepts that might not be as readily apparent through conventional means. By adopting these advanced techniques, the study aims to uncover more profound and holistic insights from the students' responses.

Co-occurrence weights are numerical values that quantify the strength or frequency of co-occurrence between entities or elements. In the context of the provided data, the co-occurrence weights represent the degree of association or alignment between the students' IDs and the teacher's viewpoint. Each entry in the data specifies the co-occurrence weight between a student's ID and the teacher's view. A higher weight indicates a stronger co-occurrence or alignment, suggesting that the student's viewpoint closely corresponds to the teacher's perspective.

These weights quantitatively measure how students' viewpoints agree with the teacher's. By analyzing and comparing these weights, we can identify the level of convergence or divergence between different individuals' perspectives within the given context. The co-occurrence weights can be used to identify patterns, similarities, or disparities in the responses and viewpoints of the students concerning the teacher's perspective. They provide valuable insights into the degree of agreement or alignment among the participants and help analyze the overall coherence or consensus within the group. From the rankings of student weights, we can observe the cognitive transition process of students during two stages of the study. Here are some descriptions based on the changes in student weight rankings:

1. In the initial lecture stage (Fig. 8), student ID 19 holds the highest weight (506), indicating that this student had a strong presence and active engagement during the discussions. Students 20, 16, and 23 also hold relatively high weights, suggesting their significant contributions to the talks.
2. After the group presentations (Fig. 9), the ranking of student weights has shifted. Student ID 8, who held the 7th position in the initial lecture stage, now has the highest weight (1128). This indicates a notable increase in their engagement and participation during the group presentations. Students 4, 19, and 15 also experienced significant rank improvements, suggesting their enhanced understanding and contributions during the reflection and presentation stages.
3. It is interesting to note that some students experienced a decrease in their weight rankings from the initial lecture to the group presentation stage. For example, student ID 21 dropped from the 14th to the 22nd position, and student ID 22 fell from the 24th to the 21st position. This suggests that these students may have had a relatively limited contribution or engagement during the group presentations compared to the initial lecture.
4. The changes in student weight rankings indicate a dynamic process of cognitive transition and knowledge assimilation. Students who initially held lower weights in the initial lecture stage, such as student ID 24 and student ID 12, made significant progress and climbed the rankings in the group presentation stage, demonstrating their active involvement and understanding of the discussed topics.
5. Overall, the variations in student weight rankings reflect the evolution of students' cognitive journeys and their level of engagement and contributions throughout the study. The orders provide insights into the shifts in students' participation, understanding, and collaboration during the different stages of the research, highlighting the dynamic nature of their learning process.

At the end of the month-long course, students were asked to provide written reflections, summarizing their thoughts and key takeaways. The reflections encompassed various aspects, including:

1. Importance of Value Exchange in Education: Students recognized the significance of value exchange systems in education. They reflected on how value exchange can foster meaningful and engaging learning experiences. Students identified the role of value exchange in promoting collaboration, creativity, and critical thinking.
2. Insights from Group Discussions: Students highlighted the value of engaging in group discussions. They acknowledged the diverse perspectives and ideas shared during these discussions. Students appreciated the opportunity to learn from their peers and gain new insights into the educational metaverse.
3. Understanding of the Seven-Layer Theorem: Students demonstrated their understanding of the seven-layer theorem in the educational metaverse. They reflected on how the theorem shaped their perception of the learner-centered environment. Students recognized the importance of the sevenlayer theorem in creating a holistic and comprehensive educational metaverse.
4. Enhancing the Value Exchange System: Students brainstormed ideas for enhancing the value exchange system in the educational metaverse. They proposed strategies to ensure an equitable exchange of educational resources and content. Students explored innovative approaches to incentivize active participation and contribution within the value exchange system.

5. Identification of Unrealizable Educational Scenarios: Students critically analyzed the limitations and constraints of the educational metaverse. They identified educational scenarios that cannot be realized within the current framework, and students reflected on the challenges and proposed potential solutions to overcome these limitations.

The group discussions and students' reflections provided valuable insights into their learning journey throughout the course. These reflections serve as a basis for further exploration and improvement in designing learner-centered educational environments and refining the value exchange system within the educational metaverse.

The process of cognitive migration can be observed from the graph, indicating that students initially recognize the relationship between the metaverse and the value exchange among individuals. Furthermore, students have come to understand that to facilitate the exchange of value between the metaverse and individuals, it is necessary to engage in immersive experiences. This signifies a progression in their understanding, highlighting the importance of experiential learning in the metaverse.

VI. Conclusions

Despite the potential of using co-occurrence graphs and text mining techniques to analyze and understand the relationships between words in a given dataset, there are some limitations and areas for future work to consider.

1. Data quality and completeness: In the context of the metaverse, ensuring the accuracy and completeness of data used for analyzing learner interactions, virtual experiences, and value exchange systems is crucial. Future work can focus on developing methods to collect comprehensive and reliable data to construct accurate models and matrices for analysis.

2. Semantic understanding: While co-occurrence graphs provide insights into word relationships, the metaverse context requires a deeper understanding of words' semantic and contextual meaning. Future research can explore techniques to incorporate semantic analysis and natural language processing to capture the nuanced meaning and context specific associations within the metaverse environment. Dynamic item analysis: The metaverse is a dynamic and evolving space. Future work can explore dynamic approaches to capture the changing nature of learner interactions, value exchange systems, and virtual experiences within the metaverse. This could involve real-time analysis of learner behavior and interaction patterns to adapt and personalize the learning experiences accordingly.

3. Integration of additional features: In addition to text mining techniques, future research can explore integrating elements such as sentiment analysis, sentiment mining, or user feedback analysis within the metaverse. This can provide a more comprehensive understanding of learners' experiences, emotions, and preferences, enabling the development of tailored interventions and personalized learning approaches.

4. Application in diverse educational contexts: While the current discussion focuses on selfdirected learning in the metaverse, future work can expand the application of these concepts to other educational contexts within Education 4.0. This could include exploring how value exchange systems, learner-centered approaches, and technology integration can be implemented in various educational settings, such as online learning platforms, virtual classrooms, or collaborative learning environments.

In conclusion, understanding the educational metaverse as a value exchange system is crucial in shaping the future of learner-centered education in the context of Education 4.0 and the Fourth Industrial Revolution. Integrating digital technologies, personalized learning experiences, and the emphasis on individual needs and goals align with the learner-centered approaches advocated in modern education. By leveraging natural interaction, text mining, and co-occurrence analysis, valuable insights can be derived from learner interactions, discussions, and reflections within the metaverse.

However, it is essential to recognize the limitations and areas for future work utilizing co-occurrence graphs and text mining techniques. Ensuring data quality and completeness, incorporating semantic understanding, and exploring dynamic item analysis is essential for capturing the complex and evolving nature of the metaverse. Additionally, integrating sentiment and user feedback analysis can provide a more holistic understanding of learners' experiences and inform personalized interventions.

Furthermore, applying value exchange systems and learner-centered approaches should not be limited to the metaverse but extended to diverse educational contexts within Education 4.0. These concepts can be implemented in online platforms, virtual classrooms, and collaborative learning environments by embracing technology integration, promoting active engagement, and fostering collaboration.

Understanding the metaverse as more than an XR platform is crucial in this rapidly changing educational landscape. It is about recognizing its potential as a personalized learning ecosystem where learners actively participate, exchange knowledge, and engage in meaningful interactions. By embracing the concept of value exchange, we can harness the power of the metaverse to cultivate deeper understanding, creativity, and collaboration among learners, ultimately preparing them for the challenges and opportunities of the Fourth Industrial Revolution.

Acknowledgement

We sincerely thank Professor Guan-Ze Liao from the Institute of Learning Sciences and Technologies at National Tsing Hua University for his invaluable guidance and insightful discussions in his research methods and analysis seminar. The

content of this course provided a crucial foundation for our study.

FUNDING INFORMATION

This study is supported by the National Science and Technology Council (NSTC), Taiwan (R.O.C.) with the project number 112-2410-H-003-006.

CONFLICTING INTERESTS

The author(s) declare that they have no conflicting interests.

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