Development of Learning Design That Amplifies Self-Regulation and Peer Interaction Among Elementary School Students in a Two-Dimensional Metaverse

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Abstract
The two-dimensional metaverse (2D-Metaverse) has been gaining momentum as a platform for executing "personalized and collaborative learning" in an online environment, in Japanese elementary education, within the purview of Society 5.0. Vital elements of this pedagogical approach are children's self-regulation and peer interaction. However, empirical studies targeting these aspects within a 2D-Metaverse are sparse. This study aims to devise a learning design that amplifies self-regulation and peer interaction among children in a 2D-Metaverse, as part of a "personalized and collaborative learning" framework. The study employed a 2D-Metaverse-based "individualized and collaborative learning" model, with 26 children from Nagasaki and Fukushima prefectures participating. The lesson design is predicated upon the concept of "reconstruction of disaster-affected areas." This pedagogical approach is architected to facilitate students' autonomy within the 2D-Metaverse, enabling them to freely navigate, as opposed to adhering stringently to instructor-led directives. The 2D-Metaverse utilized was "oVice," a web-based virtual space service. A subsequent evaluative survey, employing a 5-point Likert scale, probed the children's self-perception of "self-control" during the self-regulation learning performance phase, and their awareness of social presence through peer interaction. Owing to a non-normal distribution per the Shapiro-Wilk test, the Wilcoxon signed rank test was utilized to investigate discrepancies between each survey item and the median rating. The outcomes illustrate a positive appraisal of self-regulation and peer interaction among participants. Thus, the successful design of a pedagogical program fostering "individualized optimal learning and collaborative learning," and promoting self-regulation and peer interaction in the 2D-Metaverse, can be asserted.

Keywords: Metaverse, Self-Regulation, Peer Interaction, Elementary School

Introduction

We are confronted with the imperative of an educational framework that caters to the unique learning requisites of each pupil within an ever-evolving societal landscape, particularly in this epoch, referred to as Society 5.0. Society 5.0 epitomizes a hyper-intelligent community. In Japan, consequently, there exists an exigency to amalgamate self-directed learning with collaborative learning modalities. In the realm of 'self-directed learning', pedagogical approaches are meticulously tailored to the distinct traits and educational advancement of each learner, with a pronounced focus on nurturing competencies and aptitudes. Conversely, 'collaborative learning' cultivates interpersonal skills and honors individualism through collective educational experiences. The reverence for diversity coupled with the application of Information and Communication Technology is pivotal to this educational transformation. By actualizing education that is congruent with developmental stages, we are poised to unlock the full potential of every child. We dwell in the unpredictable epoch of Society 5.0. To thrive in this era, a radical shift in educational methodologies is indispensable.

Society 5.0 is conceptualized as a human-centric society that harmonizes economic progression with the amelioration of societal challenges through a framework that intricately intertwines cyberspace and the physical realm. This concept was introduced in Japan's 5th Science and Technology Basic Plan as the envisaged future society, succeeding the chronological progression from the hunting society (Society 1.0), through the agricultural (Society 2.0), industrial (Society 3.0), to the information society (Society 4.0). A quintessential example of the fusion between cyberspace and physical reality is the metaverse. The metaverse holds immense potential for transformative educational practices in this contemporary epoch. Figure 1 shows the conceptualization of Society 5.0.

Figure 1: Conceptualization of Society 5.0 (Cabinet Office 2024)

We shall delve into the discourse on the metaverse. Lee (2021) posits that the metaverse represents an extraordinary realm, a confluence where virtual and tangible realities coalesce and evolve symbiotically. The Metaverse Roadmap delineates four distinct categories of the metaverse: augmented reality, lifelogging, mirror world, and virtual reality. Augmented reality engenders an intelligently interactive environment. Lifelogging encompasses the

technologies dedicated to the compilation, archival, and dissemination of daily experiences and data. Mirror worlds accurately replicate our tangible environment, concurrently assimilating and providing pertinent information about the external milieu. In the educational sphere, mirror worlds manifest as virtual educational platforms, exemplified by videoconferencing systems like Zoom, Webex, Google Meet, and Teams, and two-dimensional metaverse spaces such as Gather.town. Virtual reality, on the other hand, constructs an immersive world grounded in digital data. An illustrative instance of a virtual reality tool in education is Zepeto, which enables educators to select a classroom layout, initiate a session, invite participants, and engage through voice and messages within this digital classroom setting. Figure 2 shows the taxonomy of the metaverse.

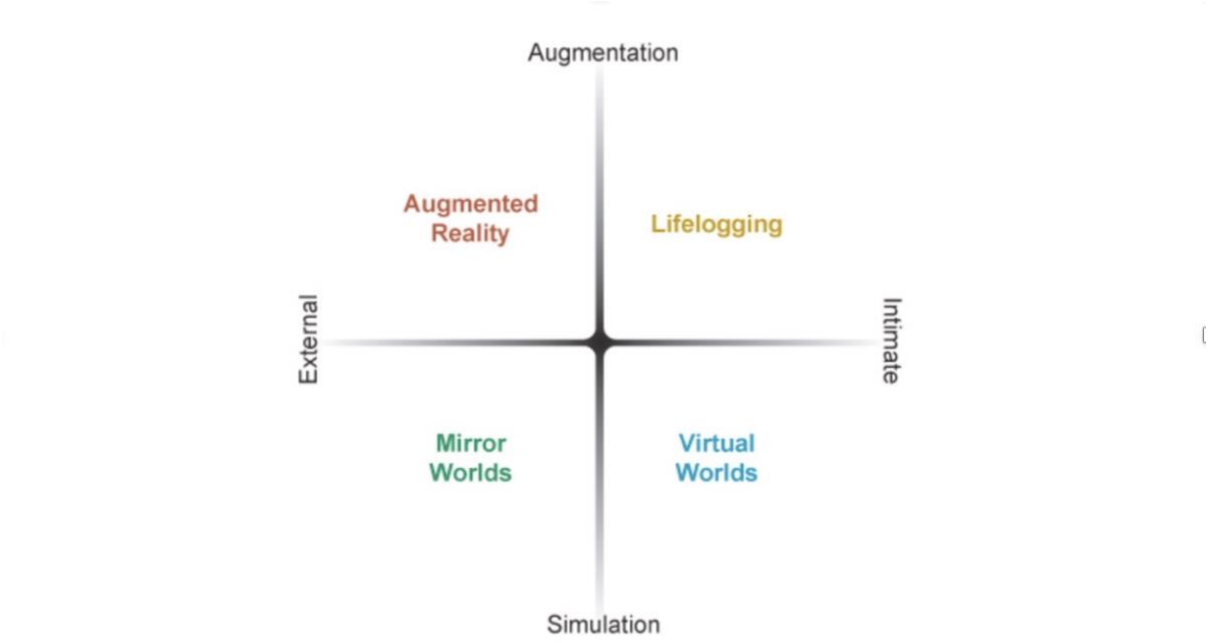

Figure 2: The taxonomy of the metaverse (World Wide Web Consortium 2008)

In this context, our attention pivoted towards the two-dimensional metaverse. This 2D-Metaverse is conceptualized as an online, virtual environment wherein avatars navigate freely across a bidimensional plane (Kurata, 2023). My focus on the 2D-Metaverse is driven by three primary reasons. Firstly, it fosters a more profound sense of social presence compared to traditional videoconferencing tools, potentially enhancing interactive learning experiences. Secondly, it provides an avenue for sharing self-directed, autonomous learning experiences with peers, which could further the amalgamation of self-regulatory and interactive learning in a digital context. Thirdly, its high usability is conducive to augmenting participant engagement, thereby empowering children to be proactive contributors to their educational journey (Sriworapong et al, 2022., McClure and Williams, 2021).

Numerous instances demonstrate the educational applications of the two-dimensional metaverse. Herein, we aim to elucidate the primary objectives of its utilization. The initial purpose serves as a support mechanism for children who are unable to attend traditional schooling. An exemplar of this is the case where a child, eager yet unable to participate in conventional classes, utilized this system as a haven for safe engagement. The second objective is to furnish a gamified learning experience. This is evidenced by scenarios where conversational interactions are intertwined with interactive games and multimedia resources, offering learners an informal, yet educationally enriching, game-based learning environment

(Zhao and McClure, 2022). The third aim is to augment online education. Traditional online learning, often reliant on videoconferencing tools, frequently lacks opportunities for individualized contact or peer-to-peer interaction. In contrast, the 2D-Metaverse enhances the realism of interactive experiences and facilitates self-regulated learning within a real-time, virtual classroom setting.

In the realm of elementary education, there exists a noteworthy instance of employing the two-dimensional metaverse: a preservice teacher's experimental lesson that amalgamates self-regulated and interactive learning methodologies (Nakashoji and Kurata, 2023). From these exploratory studies, we have articulated a series of considerations and concepts pertinent to the design and implementation of lessons in elementary schools utilizing the 2D-Metaverse framework. Nonetheless, the actual feasibility of integrating self-regulated and interactive learning within elementary school curricula remains an area of uncertainty. It is imperative, therefore, to first devise a lesson plan that seamlessly interweaves self-regulated and interactive learning elements within the context of the 2D-Metaverse. Figure 3 shows a Screen image of 2D-Metaverse.

Figure 3: A screen image of 2D-Metaverse

The objective of this research is to develop an educational design that enhances self-regulation and peer interaction among children within a two-dimensional metaverse environment. To realize this goal, we have established two methodologies. The first entails the creation and implementation of a learning framework that synergizes self-regulated and interactive learning. The second involves examining children's self-awareness of 'self-control' during phases of self-regulated learning, as well as their perception of social presence during interactions with peers.

Learning Design

Initially, we contemplated a lesson structured around the concept of weathering, focusing on the theme of Nagasaki's atomic-bombed relics. The objective of our meticulously crafted lesson is to elucidate how the denizens of Nagasaki accomplished the city's reconstruction through the endeavors of seven pivotal individuals who were instrumental in this process.

Moreover, it aims to highlight the gradual diminution in public awareness of the realities associated with the atomic bombing and the subsequent rebuilding efforts. This educational experience is tailored for 26 young learners hailing from the prefectures of Nagasaki and Fukushima. The setting for this learning endeavor is oVice, a two-dimensional metaverse platform.

This educational practice is segmented into two distinct learning phases. The initial phase entails preparatory activities prior to the lessons, while the second phase encompasses the lessons conducted within the two-dimensional Metaverse. During the preparatory study phase, the students engage in two primary activities: firstly, they conduct research on the seven individuals who played a pivotal role in the reconstruction of Nagasaki; secondly, they reflect upon and organize their thoughts regarding the person or persons who left the most significant impression on them. Within the lessons in the 2D-Metaverse, the learning process unfolds through a series of structured activities:

1. Engaging in an open-ended discussion about the individuals who left a lasting impact.
2. Participating in pair or group conversations to deliberate on the commendable efforts of those who tirelessly worked for Nagasaki's reconstruction, subsequently documenting these discussions in the chat feature.
3. Freely posing questions to one another, drawing upon the opinions expressed in the chat.
4. Conducting an unrestricted dialogue on the reasons behind the limited public knowledge of the individuals who devoted themselves to rebuilding Nagasaki.
5. Collaboratively sharing the outcomes of these discussions with the larger group.

A noteworthy aspect of this learning environment is that children are afforded the liberty to move and converse freely within the two-dimensional Metaverse. It is pertinent to mention that the duration of each lesson is set at 60 minutes.

Methods

In our research, we employed two distinct methodologies. The initial method was the implementation of a questionnaire. This questionnaire was administered to a specific demographic, comprising 26 children who participated in the lesson. The timing of its deployment was strategically planned for after the completion of the practice session. The questionnaire was designed in a 5-point Likert scale format and was facilitated through the use of Google Forms. The delineation of the scoring system is as follows: 5 very agree 4 agree, 3 neutral, 2 disagree, and 1 very disagree. The second method involved the collection of comments. The target demographic, timing, and tools for this method mirrored those used in the questionnaire. However, the format diverged, allowing for free-form text responses, enabling participants to provide more detailed and nuanced descriptions of their experiences.

We formulated a set of 11 questionnaire items focusing on the 'awareness of social presence':

1. The 2D-Metaverse is great for conversing with others.
2. I don't mind introducing myself in the 2D-Metaverse.
3. I felt like I was learning along with everyone else in lesson.
4. I don't mind participating in discussions in the 2D-Metaverse.
5. During lesson, the teacher helped me feel comfortable learning with my peers.
6. The teacher was supportive of our conversations during lesson.

7. Conversations in the 2D-Metaverse are less natural than in the classroom. (invert scale)
8. In the 2D-Metaverse, the conversation is unnatural compared to a phone call. (invert scale)
9. Conversations in the 2D-Metaverse are unnatural compared to those in a videoconference. (e.g. ZOOM) (invert scale)
10. I don't mind interacting with my peers in the 2D-Metaverse.
11. I feel that my opinions and ideas are conveyed well to others in the lesson.

The first query assessed the suitability of the 2D-Metaverse for facilitating conversations with others. The second probed the respondents' comfort level with self-introduction within this virtual space. The third item explored the sensation of communal learning experienced during the lesson. The fourth item investigated the respondents' willingness to engage in discussions in the 2D-Metaverse. The fifth focused on whether the teacher's presence enhanced the comfort level of learning alongside peers. The sixth item evaluated the teacher's supportiveness in fostering conversations during the lesson. The seventh, eighth, and ninth items, which employed an inverse scale, compared the naturalness of conversations in the 2D-Metaverse to those in a traditional classroom, over a phone call, and in a videoconference setting such as Zoom, respectively. The tenth item delved into the ease of peer interaction within the 2D-Metaverse. Lastly, the eleventh item examined how effectively the participants felt their opinions and ideas were communicated to others during the lesson.

In addition, we devised four questionnaire items to gauge 'self-perception of self-control':

1. In the 2D-Metaverse, compared to videoconferencing (e.g., ZOOM), I was able to act as I wished.
2. I was able to act while paying attention to the activity time during the lesson.
3. In the 2D-Metaverse, compared to videoconferencing (e.g. ZOOM), I was able to have conversations with people I wanted to talk to.
4. I was able to decide how to act in lesson by myself.

The first item evaluated the degree of autonomy experienced in the 2D-Metaverse compared to videoconferencing platforms like Zoom, particularly in terms of acting according to one's own wishes. The second item focused on the ability to modulate actions while being mindful of the allotted activity time during the lesson. The third item compared the ease of initiating conversations with desired individuals in the 2D-Metaverse against traditional videoconferencing settings. The fourth item assessed the extent to which participants felt they could independently decide their course of action during the lesson.

Results and Discussion

On the appointed day of the educational session, all 26 pupils partook in the lesson. The provided image captures a moment during this session. Remarkably, the lesson unfolded seamlessly without any technical glitches, adhering strictly to the preconceived design. Subsequent to the lesson, every participant completed the questionnaire. Figure 4 shows an example of a screen in practice using the 2D-Metaverse.

Table 1 delineates the outcomes pertaining to 'awareness of social presence'. Initially, an analysis was conducted to ascertain if the survey data exhibited a normal distribution. However, the Shapiro-Wilk test indicated a non-normal distribution, prompting the application of the Wilcoxon signed-rank test to examine variances between individual survey

items and the median score of 3. This analysis revealed a predominantly positive response from the majority of participants across all 11 items.

Figure 4: An example of a screen in practice using the 2D-Metaverse

Questionnaires	5	4	3	2	1	Test
The 2D metaverse is great for conversing with others.	8	9	6	1	2	**
I don't mind introducing myself in the 2D metaverse.	9	10	2	4	1	**
I felt like I was learning along with everyone else in lesson.	11	9	3	2	1	**
I don't mind participating in discussions in the 2D metaverse.	15	5	4	1	1	**
During lesson, the teacher helped me feel comfortable learning with my peers.	15	6	3	2	0	**
The teacher was supportive of our conversations during lesson.	13	9	2	2	0	**
- Conversations in the 2D metaverse are less natural than in the classroom.	10	8	5	2	1	**
- In the 2D metaverse, the conversation is unnatural compared to a phone call.	13	5	3	4	1	**
- Conversations in the 2D metaverse are unnatural compared to those in a videoconference (e.g. ZOOM)	8	6	7	4	1	*
I don't mind interacting with my peers in the 2D metaverse.	15	5	3	0	3	**
I feel that my opinions and ideas are conveyed well to others in class.	12	10	2	2	0	**

- : value inversion / Test : Wilcoxon signed rank test (compared to median 3), **p<.01, *p<.05

Table 1: The outcomes pertaining to 'awareness of social presence'

The findings for item 1, labeled " The 2D-Metaverse is great for conversing with others." revealed that 8 respondents strongly agreed (scoring 5), 9 agreed (scoring 4), 6 remained neutral (scoring 3), 1 disagreed (scoring 2), and 2 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 2, labeled " I don't mind introducing myself in the 2D-Metaverse." revealed that 9 respondents strongly agreed (scoring 5), 10 agreed (scoring 4), 2 remained neutral (scoring 3), 4 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 3, labeled " I felt like I was learning along with everyone else in lesson." revealed that 9 respondents strongly agreed (scoring 5), 11 agreed (scoring 4), 3 remained neutral (scoring 3), 2 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 4, labeled " I don't mind participating in discussions in the 2D-Metaverse." revealed that 15 respondents strongly agreed (scoring 5), 5 agreed (scoring 4), 4 remained neutral (scoring 3), 1 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 5, labeled " During lesson, the teacher helped me feel comfortable learning with my peers." revealed that 15respondents strongly agreed (scoring 5), 6 agreed (scoring 4), 3 remained neutral (scoring 3), and 2 disagreed (scoring 2), results that significantly surpassed the median rating 3 (p<.01). The findings for item 6, labeled "The teacher was supportive of our conversations during lesson." revealed that 13 respondents strongly agreed (scoring 5), 9 agreed (scoring 4), 2 remained neutral (scoring 3), and 2 disagreed (scoring 2), results that significantly surpassed the median rating 3 (p<.01). The findings for item (value inversion) 7, labeled "Conversations in the 2D-Metaverse are less natural than in the classroom." revealed that 10 respondents strongly agreed (scoring 5), 8 agreed (scoring 4), 5 remained neutral (scoring 3), 2 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item (value inversion) 8, labeled "In the 2D-Metaverse, the conversation is unnatural compared to a phone call." revealed that 13 respondents strongly agreed (scoring 5), 5 agreed (scoring 4), 3 remained neutral (scoring 3), 4 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item (value inversion) 9, labeled "Conversations in the 2D-Metaverse are unnatural compared to those in a videoconference (e.g. ZOOM)" revealed that 8 respondents strongly agreed (scoring 5), 6 agreed (scoring 4), 7 remained neutral (scoring 3), 4 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.05). The findings for item 10, labeled "I don't mind interacting with my peers in the 2D-Metaverse." revealed that 15 respondents strongly agreed (scoring 5), 5 agreed (scoring 4), 3 remained neutral (scoring 3), and 3 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 11, labeled "I feel that my opinions and ideas are conveyed well to others in class." revealed that 12 respondents strongly agreed (scoring 5), 10 agreed (scoring 4), 2 remained neutral (scoring 3), and 2 disagreed (scoring 2), results that significantly surpassed the median rating 3 (p<.01).

Table 2 delineates the outcomes pertaining to 'self-assessment of regulatory behavior.' Subsequently, the methodology for analysis is consistent with the previously delineated procedure. Consequently, it was ascertained that a preponderance of participants harbored affirmative views across all 4 items. The findings for item 1, labeled "In the 2D-Metaverse, compared to videoconferencing (e.g., ZOOM), I was able to act as I wished." revealed that 14 respondents strongly agreed (scoring 5), 7 agreed (scoring 4), and 5 remained neutral (scoring 3), results that significantly surpassed the median rating 3 (p<.01). The findings for item 2, labeled " I was able to act while paying attention to the activity time during the lesson."

revealed that 9 respondents strongly agreed (scoring 5), 5 agreed (scoring 4), 7 remained neutral (scoring 3), 3 disagreed (scoring 2), and 2 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.05). The findings for item 3, labeled "In the 2D-Metaverse, compared to videoconferencing (e.g. ZOOM), I was able to have conversations with people I wanted to talk to." revealed that 11 respondents strongly agreed (scoring 5), 8 agreed (scoring 4), 4 remained neutral (scoring 3), 2 disagreed (scoring 2), and 1 strongly disagreed (scoring 1), results that significantly surpassed the median rating 3 (p<.01). The findings for item 4, labeled "I was able to decide how to act in lesson by myself" revealed that 9 respondents strongly agreed (scoring 5), 13 agreed (scoring 4), 3 remained neutral (scoring 3), and 1 disagreed (scoring 2), results that significantly surpassed the median rating 3 (p<.01).

Questionnaires	5	4	3	2	1	Test
In the 2D metaverse, compared to videoconferencing (e.g., ZOOM), I was able to act as I wished.	14	7	5	0	0	**
I was able to act while paying attention to the activity time during the lesson.	9	5	7	3	2	*
In the 2D metaverse, compared to videoconferencing (e.g. ZOOM), I was able to have conversations with people I wanted to talk to.	11	8	4	2	1	**
I was able to decide how to act in lesson by myself	9	13	3	1	0	**

Test : Wilcoxon signed rank test (compared to median 3), **p<.01, *p<.05

Table 2: The outcomes pertaining to 'self-assessment of regulatory behavior'

Moreover, the analysis encompassed children's perspectives drawn from their open-ended responses. The opinions pertaining to interactive learning included statements such as:

> "I relished the opportunity to engage with a diverse array of individuals."
>
> "The digital interface provided an immediate sense of ease, devoid of the apprehension typically associated with in-person encounters."
>
> "It afforded me the possibility to converse with distant peers whom I desired to communicate with."

These findings indicate that children were capable of interacting with a multitude of participants within the 2D-Metaverse environment. However, there was an observation stating, "When I approached someone for a conversation, they sometimes moved away, oblivious to my intent." This incident underscores the challenges posed by the absence of social cues in the 2D-Metaverse relative to direct interpersonal interactions.

Concerning self-regulated learning, one remark was:

> "I had the autonomy to approach peers I wished to engage with."

This suggests that children had the agency to initiate information exchanges with selected peers, exercising self-direction and self-regulation. Conversely, there were expressions of uncertainty, such as "I occasionally felt directionless," and "Locating a conversational partner

proved challenging." These sentiments highlight the necessity for educators to provide individualized support tailored to the children's self-regulatory capabilities.

Conclusions

The pedagogical framework instituted in this research demonstrates the capacity to enhance self-regulatory behaviors and peer-to-peer engagement, encapsulating the integration of self-directed and collaborative learning within the 2D-Metaverse. Nevertheless, it necessitates the provision of guidance for learners who exhibit uncertainty in navigating this milieu, as well as the development of strategies to address the distinctive dynamics characteristic of the metaverse.

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