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Flowing together or alone: Impact of collaboration in the metaverse

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ABSTRACT

The metaverse is the next-generation Internet (Web3) that facilitates social connections and collaborations in a virtual world environment. Given the potential of the metaverse to provide more satisfying and effective means of remote collaborations, exploring the possibility of leveraging the metaverse for these endeavors is warranted. Therefore, an important question to address is whether greater engagement occurs when tasks are completed collaboratively versus individually in the metaverse. We address this question by drawing on flow and transportation theories to hypothesize the effect of carrying out a creative task in the metaverse collaboratively versus alone on one's cognitive absorption, a contextually relevant proxy for the flow experience. In the context of the metaverse, cognitive absorption refers to the heightened enjoyment experienced when one is immersed and "transported" into the metaverse while maintaining a sense of curiosity and control as well as perceiving a distorted sense of time. We conducted a laboratory experiment to test our research hypotheses. The results indicate that collaborations in the metaverse enhance cognitive absorption. Cognitive absorption, in turn, increases outcome satisfaction and intention to use the metaverse. The findings provide theoretical contributions by enhancing the nomological network of cognitive absorption as well as explaining how computer-mediated collaborations can facilitate the virtual transportation of users into the metaverse. The findings also offer insights and guidance for enhancing cognitive absorption and outcome satisfaction in the metaverse as well as the intention to use the metaverse.

1. Introduction

The term "metaverse" was coined in a speculative fiction named *Snow Crash* by *Neal Stephenson* in 1992. The prefix 'meta' was used to transform the word "universe" to "metaverse," suggesting the transcendence or extension from the physical world to a hypothetical synthetic or digital environment in which both worlds are closely linked [1,2]. In a metaverse, users take the form of avatars that can interact with objects and other avatars in a 3D virtual world environment. Hence, the metaverse can facilitate computer-mediated collaborations among users by creating a sense of co-presence through their embodied avatars [3]. It offers a rich, interactive, vivid, and immersive computer-mediated environment that can potentially facilitate innovation, productivity, and satisfaction [2,4,5].

The metaverse can be utilized to accomplish certain tasks and activities such as creative design [6,7]. It can support collaborative activities (e.g., design and co-creation) regardless of one's geographical location. For example, it can help lower the costs and potential risks associated with product development, as well as provide a richer and better user experience [6,8]. It can also help reduce social isolation stemming from remote and hybrid work configurations [9]. However, there are only a few empirical studies that have examined the user experience of team collaborations in the metaverse.

Of these previous studies, one experimental study by Nah et al. [10] found task complexity to increase team trust which, in turn, increases satisfaction with the team collaboration process in the metaverse. Another team collaboration experimental study in the metaverse by Schiller et al. [11] found team process satisfaction to be higher for within-boundary teams than cross-boundary teams, and the positive effect of team trust on team process satisfaction to be higher for within-boundary teams than cross-boundary teams. In a blocked design experiment focusing on gender composition of teams in the metaverse, Schiller et al. [12] found male dyads that carried out impression management to be more satisfied with their team solution, whereas female dyads and mixed-gender dyads that had invested greater effort into the task were more satisfied with the team solution. Another team

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collaboration study in the metaverse by Montoya et al. [13] found that ease of communication, coordination of task efforts, and equality of contribution among team members contributed to greater team performance whereas the frequency of communication did not contribute to team performance. In a case study by Owens et al. [14], they observed that metaverse technologies affect role clarity, shared understanding, and team coordination, suggesting that the metaverse has the potential to greatly enhance team collaboration. Although several studies [e.g., 15–21] have assessed cognitive absorption or flow experience of users in the metaverse, none of them have assessed cognitive absorption in a collaboration context. In summary, most of the earlier studies have examined team trust, team communication, and team satisfaction, but cognitive absorption or the flow experience in collaborative settings in the metaverse has not been studied. Hence, with a dearth of research, we have little understanding of the user experience when collaborating with others in the metaverse. Even though the metaverse is emerging as (and has the potential to function as) a new virtual venue to complete tasks, there is little evidence of its efficacy in enhancing the perceptions and outcomes associated with task completion [2].

While interest in capitalizing on the metaverse's potential surges [4,22], guidance and research are needed when considering configurations of participation, such as individual versus collaboration, for effectively completing tasks [23]. Although the metaverse provides a highly flexible and collaborative environment [5,9,24,25], questions remain as to whether it generates more positive experiences when completing tasks individually or collaboratively. The metaverse can support both synchronous and asynchronous collaboration in distributed settings, such as in the co-creation of product design. Group members collaborating synchronously on a task, e.g., in a geographically distributed setting, could assist each other directly in the metaverse and keep each other focused and engaged on the collaborative task, such that they experience higher immersion in the task, resulting in more positive outcomes. In contrast, individuals who are completing a task alone could be less engaged considering the nature of the metaverse being highly interactive, potentially distracting users from the task at hand [17]. Making decisions regarding whether to designate tasks to be completed individually versus collaboratively in the metaverse is important for capitalizing on the potential of this innovative technological platform [25].

Flow experience can influence one's satisfaction, performance, creativity, and well-being [26]. Although flow experience has been extensively studied in individual settings, studying it in a collaborative setting has not been as prevalent, especially in a computer-mediated or metaverse environment [27]. For studies in the literature focusing on flow in teams, the primary context has been athletics [28]. The metaverse is a rich and unique setting compared to other leaner virtual collaborative environments, creating the possibility of inducing higher levels of desirable user experiences such as the flow experience.

The metaverse has the potential to facilitate the mental transportation and immersion of geographically dispersed users into a shared virtual environment, providing a more engaging experience. More specifically, individuals may become cognitively absorbed and focused on a task to the point where they lose awareness of their surroundings and the passing of time while perceiving positive experiences and outcomes [17,26,29]. Cognitive absorption, which is a relevant proxy for the highly desirable flow experience in the context of technology usage, could enhance satisfaction with performance outcomes and behavioral use intentions [30–32]. Therefore, it is pivotal to identify the quintessential technologies, such as the metaverse, and the appropriate configuration of participation, such as individual versus collaborative, that can foster a self-rewarding experience and achieve positive outcomes. If the metaverse can foster cognitive absorption to a greater extent in collaborative tasks, it can facilitate a more engaging experience that can lead to greater satisfaction with performance outcomes and intentions to continue using the metaverse. Hence, given the importance of collaborative activities in society, this study assesses the efficacy of collaborating with others in the metaverse and the potential for the collaboration to induce greater cognitive absorption and subsequent outcome satisfaction and behavioral use intention as compared to completing tasks alone. Therefore, our main research questions are:

RQ1: Do individuals achieve a higher state of cognitive absorption in the metaverse when completing tasks alone versus collaboratively?

RQ2: Does cognitive absorption experienced in the metaverse increase outcome satisfaction and behavioral intention to use the metaverse?

To address our research questions, we draw on flow and transportation theories to examine the state of cognitive absorption of individuals completing tasks alone versus collaboratively in the metaverse. More specifically, we draw on the concept of cognitive absorption in the information systems (IS) literature and assess whether collaboration in the metaverse increases one's state of cognitive absorption. As indicated in our research questions, the overarching objective is to assess the effect of collaboration on cognitive absorption and its subsequent effects on outcome satisfaction and use intention.

Deriving the theoretical foundation from the aforementioned, we conducted a controlled laboratory experiment to assess two task completion configurations, individual versus collaborative. The findings suggest that individuals in a collaborative arrangement achieve greater cognitive absorption than individuals completing a task alone. Cognitive absorption, in turn, enhances satisfaction with the outcome and behavioral use intention. To the best of our knowledge, this is the first study that examines whether collaborating (versus working alone) in the metaverse promotes the state of cognitive absorption and the resultant effects on outcome satisfaction and behavioral use intention. This research provides implications for those interested in leveraging the metaverse to complete tasks, such as creative designs, and enhance user experiences, satisfactory outcomes, and future use intentions. It also provides guidance and insights for future research on completing tasks individually versus collaboratively in the metaverse.

2. Theoretical foundation and hypotheses

Fig. 1 presents our proposed research model depicting the effect of collaboration on cognitive absorption in the metaverse as well as how cognitive absorption influences outcome satisfaction and intention to continue using the metaverse. Specifically, in line with the IS literature in studying the flow phenomenon in a computer-mediated context, we utilize the conceptualization of cognitive absorption by Agarwal and Karahanna [32] as a proxy for the flow state. The following subsections discuss the theoretical justifications for the hypotheses.

2.1. Theoretical foundation of flow and transportation in the metaverse

In this section, we draw on the theoretical foundation of flow and transportation to explain the social facilitation of flow when collaborating with others in the metaverse. The narrative experience in the metaverse could be enhanced when collaborating with others by increasing the sense of presence and co-presence perceived by team members, giving rise to a greater flow experience.

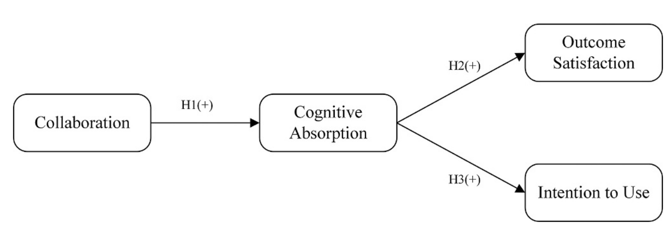

Fig. 1. Research model.

2.1.1. Theory of flow

The state of flow has been described as "an optimal state of experience in which one is completely absorbed and engaged in an activity" [17,p.734] to the point where nothing else seems to matter. Flow entails one's involvement in an activity and encompasses a variety of characteristics [33]. For instance, having a balance between the challenge presented by the task and the skill that one possesses can facilitate flow [16,34]. Having clear goals and instantaneous feedback can also help to enhance flow [35]. These circumstances can facilitate the flow experience which can be characterized by focused concentration on the task or activity, a distorted sense of time, loss of one's self-consciousness, the merging of one's action and awareness, feelings of being in control, an autotelic or self-rewarding experience, and enjoyment [34,36,37]. The flow experience can be present in a variety of contexts, including computer game play, creating artistic works, participating in sports, and performing surgery [34].

Flow theory has provided a foundation for the conceptualization of constructs such as cognitive absorption to explain "holistic experiences with IT" [32]. Cognitive absorption is "a state of deep involvement with software" [32,p.673] and has been shown to increase behavioral intentions, perceived ease of use, and perceived usefulness. Similar to prior IS studies [e.g., 32,38], we conceptualize flow as cognitive absorption. More specifically, the dimensions of temporal dissociation (or time distortion), focused immersion, heightened enjoyment, and control are analogous to flow dimensions [32]. The additional dimension of curiosity, adopted from Trevino and Webster [39] and Webster et al. [40], provides greater elucidation to the flow experience in the context of technology usage. This fifth dimension captures the intensification of one's "sensory and cognitive curiosity" [32,p.668] and is closely related to autotelic experience, an important dimension of flow [37].

2.1.2. Transportation theory

Transportation theory proposes that individuals can immerse in a narrative such that they mentally "travel" to or get "transported" into an alternate world [41]. Narratives are structured with discernible plots that commence with an introduction and eventually reach a conclusion. Similar to narratives, activities in a metaverse can pose real-world problems that need to be resolved for tasks to be completed, such that these activities or tasks begin with an introduction to the overarching goal or objective to be reached along with instructions to complete them. Metaverse experiences serve as a potential conduit for one to mentally transfer from the physical to the virtual environment, facilitating the state of flow or cognitive absorption. Individuals can become deeply immersed in a narrative and attached to or engaged with characters in it [41,42].

Outcomes from this transportation experience include losing one's awareness of realities or their physical surroundings [41]. In the context of the experience encountered with narratives, transportation refers to "a convergent mental process, a focusing of attention, that may occur in response to either fiction or nonfiction. The components of transportation include emotional reactions, mental imagery, and a loss of access to real-world information" [41,p.703]. The more involved an individual becomes in a virtual world, the greater the extent of presence that can be experienced. Stimuli from physical and virtual environments contend for the "focal consciousness of the individual" [43, no pagination]. Due to the limitation of one's sensory channel and boundaries on one's cognitive processing capabilities, one's concentration becomes focused on the virtual environment stimuli. In other words, "auditory presence or visual presence" [43, no pagination] in the real world is disregarded, which is highly probable considering the immersive nature of the metaverse. Losing access to reality, such as one's awareness of time, can be elemental to mental transportation occurring in which one is transported from an existing physical environment to a narrative environment such as the metaverse.

2.1.3. Social facilitation of flow

Flow experience in a social setting can occur when an individual is collaborating with others to complete a task [44,45]. Studies have found that individuals collaborating in a team can facilitate or enhance the flow experience of their teammates [28,46]. For instance, a teammate can help others focus on the task by reducing distractions, providing feedback regarding their progress, or contributing the requisite skills to meet the challenge of the task. These components of flow can be ingrained in the team dynamics and leveraged by individuals to support their flow experience as well as enhance others' flow states. Research suggests that individuals working in dyads to solve puzzles experienced greater flow than those working individually when the levels of challenge were moderate or high [47]. However, to the best of our knowledge, no research has examined individuals collaborating in a metaverse dedicated to creative tasks (i.e., with no correct answer) that entail idea generation and design co-creation.

When individuals are working on a common task or toward a collective goal, they can help each other stay focused on the task [28]. Social facilitation can enhance one's drive in the presence of others [48], causing one to be more focused and absorbed in the collaborative task to the point where it facilitates ignoring distractions that might divert attention away from the objective to accomplish. Previous neuroscience research has demonstrated an increase in task attention in the presence of another person versus being alone when viewing stimuli with high hedonic or emotional value [49].

Further, as each team member is working toward a shared goal, it is imperative for them to stay focused so they can effectively collaborate with the other members of the team [28]. They need to be aware of their teammates' actions and the progression of task completion so they can respond accordingly to achieve the team's objective. In other words, individuals in a team are more likely to stay focused on the task as well as assist their teammates to stay focused to achieve successful outcomes. For example, a team member can help the teammate(s) with a certain aspect of the task, so they are less likely to become bored, distracted or frustrated and, hence, become more immersed in the task, resulting in greater focused concentration. Social facilitation and the sense of co-presence in the metaverse can increase an individual's arousal, thereby resulting in positive outcomes such as cognitive absorption [50–52]. Previous findings suggest that individuals experience greater social presence with avatar e-mail versus traditional e-mail [53]. Individuals can become attached to their avatar, which facilitates a sense of embodiment of their avatar and a sense of presence in the metaverse [3]. Collaborating with others in the metaverse further enhances the sense of co-presence with other team members through their embodied avatars, thereby facilitating a greater sense of being "transported" into the metaverse.

When individuals are collaborating on relatively straightforward tasks, social facilitation can foster better experiences and outcomes [48], such as cognitive absorption. When collaborating in teams in the metaverse, an individual will need to attend to their teammate(s) in completing their collaborative task, which directs attention to the virtual environment and away from their physical surroundings. When individuals are collaborating with others in the metaverse, they become more absorbed in completing the tasks collectively and progressing toward their goal, causing one to lose their awareness of the passing of time [28]. An allocation of cognitive resources occurs between tracking time and attending to stimuli in the task [54], as well as attending to one's teammate when the task is collaborative which reduces one's awareness of time [55]. In a previous study of acceptable waiting room times, greater discrepancies between actual and estimated wait time occurred in the presence of others versus when waiting alone [56]. In a collaborative work setting which typically includes a clear collective goal, individuals exhibit focused immersion to engage in their contribution to the team's efforts, which enhances their cognitive absorption. Hence, we hypothesize that individuals collaborating with others in the metaverse will experience greater cognitive absorption than those completing tasks alone. Hence, we hypothesize that:

H1: *Individuals completing tasks collaboratively in the metaverse experience higher cognitive absorption than individuals completing tasks alone.*

2.2. Enhancing outcome satisfaction and intention to use

Enjoyment, which is a positive emotion and one of the dimensions of cognitive absorption, is referred to as "capturing the pleasurable aspects of the interaction" [32,p.673]. Contentment resulting from the pleasurable experience increases and broadens one's cognition to facilitate the generation of new perspectives and ideas [57,58]. This positive emotion can build durable cognitive and psychological resources [58], which increase both cognitive capacity and affective outcomes. With enhancements in intellectual resources resulting from cognitive absorption, users produce quality outcomes, such as from a creative design task. Hence, cognitive absorption can help increase outcome satisfaction, which is one's evaluation of the performance outcomes. Previous studies have also identified improvements in task performance that result from the sense of presence or immersion, which is closely related to cognitive absorption or flow, as well as from the immersive experience of using a virtual world [59,60]. Therefore, the following hypothesis is proposed:

H2: *Cognitive absorption positively influences outcome satisfaction.*

Enjoyment is a dimension of cognitive absorption and encompasses the pleasure one derives [32]. As noted in the extant literature, "flow, or the enjoyment experienced…represents a form of interest" [57,p.305]. Interest has conceptual similarities to being curious which facilitates a desire to explore, interact with, and become more familiar with a given object. This inquisitiveness suggests that "the openness to new ideas, experiences, and actions is what characterizes the mindset of interest as broadened" [57,p.305]. Interest is also considered relevant to situations in which one perceives probabilities of attainment [57]. Hence, the interest one experiences with flow or cognitive absorption can enhance one's motives to continue interactions and experiences with a given object or phenomenon. Previous research has found flow and cognitive absorption to positively influence intentions to use a virtual world directly [61] as well as indirectly through attitude toward a virtual world [21]. Therefore, we hypothesize that:

H3: *Cognitive absorption positively influences intention to use.*

3. Research method

We conducted a between-subject experimental study to empirically test our research model. We recruited 218 subjects from multiple sections of an Introduction to Management Information Systems undergraduate course at a large university in the Midwestern United States and randomly assigned each section to the collaboration (i.e., working with another individual) or individual (i.e., working alone) condition. The study was conducted in a computer laboratory. Each student took on a standard avatar in the virtual world, *Second Life*, that is consistent with their gender. The subjects then carried out a design task in *Second Life*, which provided a three-dimensional digital space that facilitated interactive, immersive experiences. Subjects assigned to the collaboration condition were randomly assigned to teams of two in which they collaborated with an anonymous teammate (who was seated on a different side of the computer lab) to complete the assigned design task. Subjects in the individual condition completed the same task alone.

3.1. Experimental procedure and task

There are three main parts in the experimental procedure:

1) *Training*: Subjects were provided with a tutorial handout and given three minutes to practice four basic actions: (i) moving their avatar; (ii) moving an object; (iii) rotating an object; and (iv) changing their perspective (i.e., view) in the virtual world.
2) *Showroom design task*: Based on the assigned experimental condition, subjects either worked alone or collaborated with a randomly assigned virtual partner in *Second Life* to create a showroom design for a large furnishing company (see Fig. 2). The furniture (i.e., a set of 12 items) required for the task was made available on a digital showroom platform. Subjects were given 15 minutes to create a showroom design within the platform assigned to them. When 15 minutes were up, the subjects proceeded to the next step.
3) *Post-study questionnaire*: Subjects filled out a questionnaire on Qualtrics that captured their demographic information, whether they completed the design task, and the variables in this study. We provide these variables and their measurement scales in the next subsection.

3.2. Measurement

The questionnaire included measurement items for cognitive absorption, outcome satisfaction, and intention to use. Following Agarwal and Karahanna [32], we modeled cognitive absorption as a second-order construct comprising five dimensions–Temporal Dissociation, Focused Immersion, Heightened Enjoyment, Curiosity, and Control. The measurement scales for Outcome Satisfaction and Intention to Use were adapted from [21,62] respectively. All items were captured using a 7-point Likert scale (and are presented as part of Table 2).

3.3. Data analysis and results

We recruited 218 subjects for the experiment. After the random assignment, 82 subjects participated in the individual condition and 136 (i.e., 68 teams) subjects participated in the collaboration condition. We dropped four subjects in the individual condition and four subjects (i.e., two teams) in the collaboration condition because they did not complete the design task within the time allotment of 15 minutes. The final sample size is 210, with 78 subjects in the individual collaboration and 132 subjects (i.e., 66 teams) in the collaboration condition. The majority (i.e., 94%) of the subjects were 19 to 25 years old, and 91% had 6 to 15 years of computer experience. Among the subjects, 64% were male and 36% were female. The subjects considered themselves experienced in the virtual world (i.e., for the measurement item "I consider myself to be experienced in the 3D virtual world environment," the average response was 5.5 out of 7).

Since the two individuals working in a collaboration group may affect each other in experiencing cognitive absorption, we applied

Fig. 2. Furniture on the showroom platform.

intraclass correlation (ICC) to test the dependence of the two members of a group [63]. The test results showed insignificant ICC statistics for cognitive absorption (ICC = 0.263, *p*-value = 0.11), suggesting no significant group dependence in terms of cognitive absorption experience. Thus, we model cognitive absorption at the individual level for all subjects, i.e., those working in a collaborative group and individually. Similarly, insignificant ICC statistics were obtained for outcome satisfaction (ICC = 0.144, *p*-value = 0.266) and intention to use (ICC = −0.273, *p*-value = 0.834), suggesting that individuals working in a collaboration group were not influenced by their partner in perceiving outcome satisfaction and intention to use. Table 1 shows the descriptive statistics of all indicators.

3.4. Measurement model

A confirmatory factor analysis (CFA) using covariance-based structural equation modeling (CB-SEM) was conducted to assess the validity of our measurement model. Specifically, the CB-SEM software, Mplus, version 8 was used. We modeled each measurement item as a reflective indicator of its underlying latent variable. Latent variables–Outcome Satisfaction, Intention to Use, and the second-order construct, Cognitive Absorption–were allowed to covary with each other. The measurement model was estimated by a robust maximum likelihood estimator for CB-SEM. Table 2 presents each measurement item's loading on its construct and its variance explained by the construct, while Table 3 shows the construct reliability and discriminant validity.

First, we evaluated *convergent validity* by examining factor loadings. As shown in Table 2, all factor loadings are significant at *p*-value < 0.001. All measurement items have a loading exceeding 0.6, the threshold suggested to establish convergent validity [67].

Then, *construct reliability* was assessed by calculating Cronbach's alpha and composite reliability (CR) for each construct. As Table 3 shows, Cronbach's alpha coefficients ranged from 0.822 to 0.978, exceeding the recommended level of 0.7 [68]. CR of all constructs are in the range from 0.856 to 0.978, all larger than the suggested cutoff of 0.7 [69].

To evaluate *discriminant validity*, we checked the average variance extracted (AVE) and inter-construct correlations. As Table 3 shows, AVE scores range from 0.566 to 0.938, exceeding the recommended cutoff of 0.5 [70]. In addition, the square root of AVE for each construct is larger than its correlation coefficients with other constructs. Both the AVE scores and the inter-construct correlations suggest an acceptable level of discriminant validity for all constructs.

Lastly, we evaluated the measurement model by examining the overall fit of the CFA model to the observed dataset. The CFA model has a chi-square value of 410.599 with 290 degrees of freedom (*p*-value < 0.001). The goodness-of-fit of the CFA model is determined by a set of

Table 1
Descriptive statistics of indicators.

Construct	Item	Aggregate Data (*N* = 210)		Collaboration Condition (*N* = 132)		Individual Condition (*N* = 78)	
		Mean	St. Dev.	Mean	St. Dev.	Mean	St. Dev.
Temporal Dissociation	TD1	5.281	1.242	5.432	1.160	5.026	1.338
	TD2	4.548	1.595	4.667	1.619	4.346	1.544
	TD3	4.824	1.465	4.985	1.370	4.551	1.584
	TD4	4.690	1.536	4.871	1.464	4.385	1.614
Focused Immersion	FC1	4.586	1.329	4.750	1.292	4.308	1.351
	FC2	4.624	1.347	4.795	1.335	4.333	1.326
	FC3	4.790	1.250	4.962	1.238	4.500	1.225
Heightened Enjoyment	EJ1	5.257	1.049	5.364	1.013	5.077	1.090
	EJ2	4.876	1.239	4.970	1.260	4.718	1.194
	EJ3	5.148	1.150	5.258	1.137	4.962	1.156
	EJ4	5.248	1.176	5.333	1.157	5.103	1.202
Curiosity	CR1	4.862	1.204	4.795	1.288	4.974	1.044
	CR2	4.681	1.225	4.705	1.312	4.641	1.069
	CR3	4.676	1.253	4.720	1.298	4.603	1.177
	CR4	4.762	1.234	4.795	1.288	4.705	1.141
Control	SC1	5.581	1.216	5.538	1.250	5.654	1.160
	SC2	5.595	1.037	5.598	1.010	5.590	1.086
	SC3	5.562	1.071	5.523	1.073	5.628	1.070
	SC4	5.662	1.155	5.652	1.204	5.679	1.075
Outcome Satisfaction	OS1	5.395	1.045	5.379	1.129	5.423	0.890
	OS2	5.433	1.088	5.500	1.037	5.321	1.168
	OS3	5.443	1.076	5.485	1.045	5.372	1.129
	OS4	5.424	1.118	5.462	1.094	5.359	1.162
Intention to Use	IU1	3.114	1.570	3.038	1.584	3.244	1.547
	IU2	3.067	1.570	2.962	1.560	3.244	1.581
	IU3	3.181	1.627	3.106	1.645	3.308	1.598

Table 2
Constructs, measurements, and CFA results.

Constructs	Item	Loading	*Z*-value	R^2
Temporal Dissociation [32]	TD1: When I was carrying out the design task in Second Life, time appeared to go by quickly.	0.853***	34.867	0.727
	TD2: … I lost track of time.	0.813***	24.116	0.662
	TD3: … time just flew by.	0.892***	43.251	0.796
	TD4: … I spent more time than I had realized.	0.801***	26.221	0.641
Focused Immersion [32,40,64]	FC1: When I was carrying out the design task in Second Life, I was totally absorbed in what I was doing.	0.930***	55.500	0.866
	FC2: … I was immersed in the task.	0.924***	57.138	0.854
	FC3: … I was completely focused on the task.	0.866***	36.809	0.750
Heightened Enjoyment [32,65]	EJ1: When I was carrying out the design task in Second Life, I was having fun.	0.929***	76.398	0.862
	EJ2: …it provided me with a lot of enjoyment.	0.898***	50.290	0.807
	EJ3: …I was enjoying the task.	0.970***	172.369	0.941
	EJ4: …I found the task interesting.	0.930***	75.851	0.865
Curiosity [32,65]	CR1: I was curious when designing in Second Life.	0.877***	39.467	0.768
	CR2: Designing in Second Life excited my curiosity.	0.940***	80.500	0.883
	CR3: Designing in Second Life made me curious.	0.929***	67.228	0.862
	CR4: Designing in Second Life aroused my imagination.	0.946***	87.231	0.895
Control [32,66]	SC1: When carrying out the design task, I felt confused. (reverse)	0.720***	11.892	0.519
	SC2: …I felt calm.	0.641***	11.795	0.411
	SC3: …I felt in control.	0.614***	10.621	0.377
	SC4: …I felt frustrated. (reverse)	0.802***	18.864	0.644
Outcome Satisfaction [62]	OS1: I am happy with the design I came up with.	0.823***	19.028	0.677
	OS2: I like the outcome of my design effort.	0.981***	128.202	0.962
	OS3: I believe I have created a great design for the [brand name] showroom.	0.953***	89.999	0.907
	OS4: I am satisfied with my design of the [brand name] showroom.	0.860***	33.838	0.740
Intention to Use [21]	IU1: I intend to use Second Life in the next 6 months.	0.972***	109.307	0.945
	IU2: I plan to continue using Second Life in the next 6 months.	0.973***	101.458	0.946
	IU3: I expect to visit sites in Second Life in the next 6 months.	0.961***	93.697	0.923

*** $p < 0.001$; Brand name was removed to maintain anonymity.

Table 3
Construct reliability, discriminant validity, and correlation.

Construct	Alpha	CR	AVE	1	2	3	4	5	6	7
1. Temporal Dissociation	0.903	0.900	0.701	**0.838**						
2. Focused Immersion	0.932	0.935	0.826	0.485	**0.909**					
3. Heightened Enjoyment	0.961	0.964	0.867	0.511	0.624	**0.931**				
4. Curiosity	0.958	0.959	0.853	0.468	0.571	0.601	**0.924**			
5. Control	0.822	0.856	0.566	0.142	0.174	0.183	0.168	**0.752**		
6. Outcome Satisfaction	0.947	0.948	0.823	0.202	0.247	0.260	0.238	0.072	**0.907**	
7. Intention to Use	0.978	0.978	0.938	0.327	0.399	0.420	0.385	0.117	0.121	**0.968**

Bold values are the square root of AVE.

index criteria. The normalized chi-square (χ^2/df) is 1.416, less than the recommended value of 3.0. The CFA model fit has CFI (comparative fit index) = 0.974, TLI (Tucker-Lewis index) = 0.971, RMSEA (root mean square error of approximation) = 0.045, and SRMR (standardized root mean square residual) = 0.078, suggesting a good fit of the measurement model to the data [71].

3.5. Structural model

After confirming the reliability and validity of the construct measures, we assessed the structural model that represents the underlying research model. We included gender as a control variable in the structural model to explain cognitive absorption, as prior studies suggested that gender influences flow experience [72,73]. Similar to the measurement model, the structural model was estimated by using a robust maximum likelihood estimator. The fit indices of the structural model include: $\chi^2 = 496.129$, df = 340, χ^2/df = 1.46, CFI = 0.968, TLI = 0.965, RMSEA = 0.047, and SRMR = 0.077, meeting the cutoff criteria recommended by Hu and Bentler [71]. The fit indices suggest that the structural model fits the data well. Fig. 3 presents the results of structural model estimation.

As shown in Fig. 3, individuals working collaboratively experience a higher level of cognitive absorption than individuals working alone (β = 0.268, p-value < 0.05). Thus, hypothesis H1 is supported. In terms of the effects of cognitive absorption on outcome satisfaction and intention to use, the empirical results indicate that cognitive absorption positively affects outcome satisfaction (β = 0.312, p-value < 0.001) and intention to use (β = 0.517, p-value < 0.001). We also tested the effects of cognitive absorption on outcome satisfaction and intention to use separately for the collaboration and individual conditions, and the effects remain positive and significant. Thus, both hypotheses H2 and H3 are supported.

3.6. Common method bias

Given that our data were cross-sectional and collected using a self-reported questionnaire at the end of the experiment, common method effects might exist that could lead to biased estimates of reliability and validity of the measurement model, as well as potential biased estimates of relationships between latent constructs [74,75]. Thus, we conducted statistical analyses to examine the severity of common method bias.

First, we examined the correlation matrix of constructs (refer to Table 3). As all correlation coefficients are below 0.9 (the highest correlation is 0.624), there is no evident threat of common method bias in the data [76,77]. Then, we performed Harman's single-factor test by conducting an exploratory factor analysis in which all measurement items were loaded onto a single factor without rotation [75]. Harman's test showed that the single factor only explains 37.3% of the variance, suggesting no or minimal threat of common method bias in the data.

Following the recommendations for controlling method biases by Podsakoff et al. [75], we further applied the single-common-factor approach to statistically control for method effects. Since identification problems might be present when using CB-SEM, we followed the PLS-based approach by Liang et al. [78]. Specifically, we introduced a

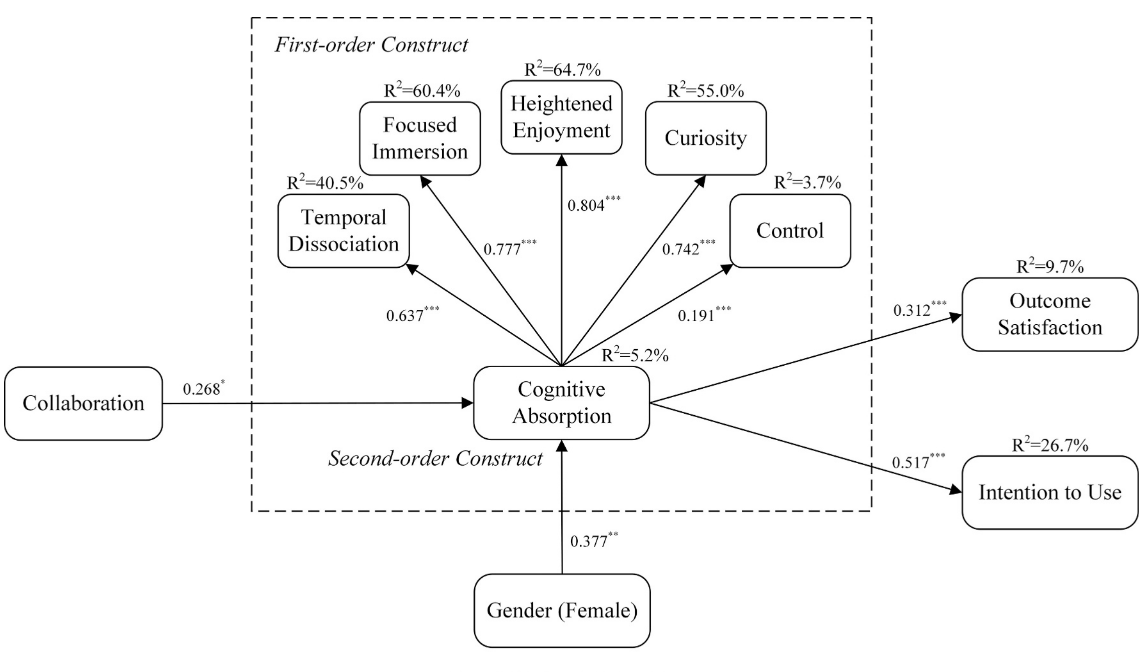

Fig. 3. Results of structural model.

common method factor that is linked to all constructs' indicators and then calculated each indicator's variance substantively explained by its principal construct as well as its variance explained by the common method factor. The average variance substantively explained by principal constructs is 0.843, whereas the average variance explained by the common method is 0.003. The ratio of substantive variance to method variance is about 255:1. Furthermore, most of the common factor loadings are not significant. The single-common-factor analysis provides evidence that there is no serious threat of common method bias.

3.7. Mediation analysis

Our proposed research model suggests two important mediation effects including: (1) cognitive absorption mediating the effect of collaboration on outcome satisfaction, and (2) cognitive absorption mediating the effect of collaboration on intention to use. To test those mediation effects, we conducted a mediation test at the structural model level. Bias-corrected 95% confidence intervals of indirect effects were calculated using 10,000 bootstrap iterations. The mediation effects were categorized using the typology suggested by Zhao et al. [79]. Table 4 summarizes the results of the mediation analysis.

As Table 4 shows, the direct effect of collaboration on outcome satisfaction is not statistically significant, whereas the indirect effect via cognitive absorption is significant with bias-corrected 95% CI = [0.007, 0.253]. The results suggest that the effect of collaboration on outcome satisfaction is indirect and is fully mediated by cognitive absorption (a.k.a. indirect-only mediation based on Zhao et al.'s classification [79]). Similarly, the results show that the indirect effect of collaboration on intention to use via cognitive absorption is statistically significant (bias-corrected 95% CI = [0.004, 0.366]). Since the direct effect of collaboration on intention to use is also significant ($\beta = -0.332$, p-value < 0.05), our results indicate that cognitive absorption partially mediates the effect of collaboration on intention to use [79]. Given the partial mediation of collaboration on use intention via cognitive absorption, we conducted an overall analysis of the effect of collaboration on use intention and found the total effect to be insignificant ($\beta = -0.152$, p-value $= 0.291$), suggesting that the direct and indirect paths have complementary effects that cancel out each other.

4. Discussion

The metaverse has emerged as an innovative technology that offers promising opportunities, creating a need for guidance to adapt and use it effectively. With considerations of working remotely or in dispersed locations, it is essential to identify the platforms that are most conducive to promoting engagement such that individuals can derive satisfaction with the outcomes of their endeavors. Drawing upon flow and transportation theories, we investigate the effect of collaboration (versus working in solitude) on the flow experience, using cognitive absorption, and the mental "transportation" into the metaverse. We also assess the effects of this experience on satisfaction with outcomes and intentions to use the metaverse in the future. By focusing on the context-specific proxy for flow, i.e., cognitive absorption, this study unveils the experience of flow specifically in a metaverse-enabled collaborative environment and its influence on satisfaction with outcomes and future use intentions. Table 5 summarizes the results of hypothesis testing.

Specifically, we found that the collaborative (versus individual/solidarity) configuration enhances the flow experience, which addresses our first research question. This experience augments intentions to use a virtual world in the future as well as leads to a higher level of satisfaction with the outcomes, which answers our second research question. Our results suggest that individuals can become highly focused on the task and have complete concentration on activities in the metaverse environment, especially when they collaborate with a partner. When collaborating with a partner, individuals can assist each other with properly aligning and maintaining their concentration on the task [54]. For instance, teammates can help remove or reduce distractions to enhance engagement and involvement in their collaborative task.

Table 5
Summary of hypothesis testing.

#	Hypothesis	Supported?
H1	Individuals completing tasks collaboratively in the metaverse experience higher cognitive absorption than individuals completing tasks alone.	Yes
H2	Cognitive absorption positively influences outcome satisfaction.	Yes
H3	Cognitive absorption positively influences intention to use.	Yes

This research provides a theoretical foundation for understanding the flow experience in the metaverse in a collaboration context, and theoretical implications are elaborated next.

4.1. Implications for theory

This study makes important theoretical contributions by: (1) assessing cognitive absorption, as the proxy of the flow experience, in the context of the metaverse, (2) extending the nomological network of cognitive absorption by evaluating collaboration as its antecedent, as well as outcome satisfaction and behavioral use intention as its consequences in the metaverse environment, and (3) extending the theories of flow and transportation which provide insights into the ability to experience embodied social presence in a collaboration context that facilitates transportation into the metaverse.

First, previous research has been inconsistent in operationalizing flow [80]. Our findings underscore the importance of utilizing a contextually relevant construct, i.e., cognitive absorption. More specifically, cognitive absorption is particularly relevant when assessing a state of extensive involvement in a technological domain [32]. We utilized cognitive absorption as a proxy for flow considering the unique nature of the metaverse. Interestingly, we found that among the five dimensions of cognitive absorption, control is the least important and relevant in the context of the metaverse. We postulate that if users are highly proficient with technology use and the technology (i.e., in this case, the metaverse) is easy to use and navigate, all users will perceive a high sense of control, which downplays the relevance of control in modeling cognitive absorption as a second-order construct. Hence, based on our findings, we suggest that control could be a necessary condition for cognitive absorption rather than a dimension of cognitive absorption. Future research is warranted to assess the role of control in cognitive absorption, particularly in the metaverse environment.

Second, in assessing and enhancing the nomological network of cognitive absorption, we found that cognitive absorption was not only relevant to and enhanced by collaboration but also influenced

Table 4
Mediation analysis results.

Mediation Path	Direct Effect	Indirect Effect	SE	Bias-C. 95% CI		Mediation
				Lower	Upper	
Collaboration → Cognitive Absorption → Outcome Satisfaction	0.038	0.096	0.061	0.007	0.253	Indirect-only mediation
Collaboration → Cognitive Absorption → Intention to Use	−0.332*	0.170	0.093	0.004	0.366	Complementary mediation

*$p < 0.05$; Bias-C. 95% CI represents the bias-corrected 95% confidence intervals of the indirect effects.

satisfaction with the task outcome and behavioral use intention. Hence, collaboration is a key antecedent in the nomological network of cognitive absorption, whereas outcome satisfaction and use intention are consequences. Interestingly, collaboration also has a direct effect on use intention. A possible reason is that although the metaverse offers a rich and interactive virtual environment to facilitate cognitive absorption in collaborations, individuals still have the preference to collaborate with each other face-to-face versus via the metaverse if they have the choice. Additionally, we found that females experience greater cognitive absorption than males. This finding is consistent with a flow study in the setting of digital game-based learning [72] but contrary to a study on Internet use [73]. Our empirical findings reveal the importance of considering individual characteristics such as gender when theorizing and expanding the nomological network of cognitive absorption.

Third, although the phenomenon of flow can occur in various settings such as performing surgery or playing chess, transportation theory provides a potential contextual explanation for the experience of flow in the metaverse. Transportation theory proposes that individuals can mentally travel to a narrative world when they become cognitively absorbed in a narrative [41]. More specifically, individuals can be engaged as "viewers, or any recipient of narrative information. Whether the narrative is fictional or nonfictional, the same processes involved in transportation are theorized to occur." [41,p.702]. In the context of engaging in activities in the metaverse, an individual can focus attention on the events occurring in the virtual environment and lose touch with reality such that one becomes transported into or perceives "presence" in the virtual environment (i.e., narrative world) [81]. Narrative worlds are a broad-based conceptualization that extends beyond written stories to include, in the context of this study, events in the metaverse. Based on the results of this study, we provide a more coherent understanding of "how" and "why" the flow phenomenon can occur in a particular context (i.e., the metaverse).

Completing an activity with others can facilitate "a shared state of holistic focus" [28,p.411] where teammates are "transported" into the same space in the metaverse to work together on a task. Previous research has demonstrated the effects of social facilitation in the virtual environment, which is in line with the concept of embodied social presence in the metaverse [3]. In the context of the metaverse, using one's embodied avatar to carry out activities such as navigating the virtual world, moving objects in the virtual world, and communicating with others through their computer-mediated avatars enhance one's sense of presence and co-presence with other avatars in the metaverse [3]. Hence, performing tasks in the metaverse with collaborators enhances virtual transportation into the metaverse to create a deeper and holistic flow experience among team members.

4.2. Implications for practice

Our research findings suggest that the metaverse can be used to facilitate collaborative activities to foster a greater flow experience. Individuals can become more immersed and cognitively absorbed in the activities in the metaverse when collaborating with a partner, such that higher levels of satisfaction with task outcomes can be realized. Although individuals working in solidarity can utilize virtual spaces and experience flow, working collaboratively can facilitate a greater flow experience. In line with the extant literature, we also found that flow experience can influence use intention [82].

We highly recommend the use of the metaverse (or similar technological platforms) for collaborations in tasks such as creative design, especially given the positive satisfaction with outcomes. Carrying out design co-creation in the metaverse can help increase satisfaction with the designs. Organizations may use the metaverse to facilitate collaborative design to help increase the perceived quality of the design and the overall satisfaction with the design.

Organizations can utilize the metaverse for collaborations as it offers an immersive environment that induces a highly engaging and enjoyable experience termed flow or cognitive absorption. The metaverse helps to facilitate engagement and enjoyment, which give rise to a highly creative process [58,83,84]. The social facilitation from working with others in the metaverse further enhances the creative process [85,86]. Hence, the use of the metaverse for collaborative design may enhance creativity to produce higher quality and satisfying designs.

Based on the findings from our study, the metaverse is a viable option for collaborative tasks as it has the potential to facilitate a greater flow experience which leads to greater satisfaction with outcomes. For instance, the metaverse could be used by organizations to carry out training and onboarding of employees [87]. Considering that the metaverse has the potential to provide a satisfying experience, doing so may assist with increasing satisfaction. Hence, virtual environments similar to the metaverse can create opportunities to experience flow, and this experience is more pronounced when collaborating with someone.

Additionally, our findings can be adapted to situations in which virtual collaborations have been challenging or limited by prior existing technologies to enhance engagement and performance outcomes. For example, our findings could be applied to the practice of pair programming, a widely used software development technique whereby two coders work collaboratively on a programming task [88]. Traditional pair programming is usually practiced by collocated teams, requiring two coders to work together in front of the same workstation [89]. Although distributed or virtual teams can also apply pair programming by using video conferencing and screen sharing tools [89,90], significant challenges may exist such as hindered communication within the team, lack of awareness of others, and difficulty of accessing physical objects [91]. The findings of this research suggest that inducing flow in a collaborative environment is an important solution to address limitations of the current practice of distributed pair programming, where the metaverse could help overcome these limitations. With the increasing trend of transitioning to remote work and virtual teams, the metaverse offers an ideal platform to set a more immersive and interactive programming space for even more effective collaborations. Hence the metaverse has the potential to overcome challenges for distributed teams, such as in pair programming and other collaborative tasks.

4.3. Limitations and future research

Our research has some limitations that can be considered in future research. First, our collaborative activities consisted of teams of two individuals. However, as the team size increases, the effect of collaboration on flow and outcome satisfaction may become more complex. For instance, issues such as delays in making decisions may be more prevalent. The generalizability of our findings to teams of larger sizes (i.e., three or more) can be assessed in future research. Second, the context of our study was performing a creative design task (i.e., designing a showroom for a home furnishing store). Future research can explore other contexts such as shopping or social networking activities. Third, our study was conducted in the metaverse only. Future studies can extend this study to non-metaverse settings such as software applications that provide platforms for collaboration. Fourth, we used student subjects in a lab experimental setting to achieve a high level of control and internal validity in comparing individual versus collaborative activities in the metaverse, which may limit the external validity of the findings. Future efforts can utilize other research designs such as observational studies to triangulate our findings and explain the impact of collaboration in the wider application of the metaverse and in other specific contexts such as the working environment. Future research can also explore the introduction of gamification and its effects on the flow experience in the metaverse. Gamification can be evaluated in both team and individual tasks, and assessments can be made of satisfaction with the experience and task outcomes. Our study focused on collaborations in a peer-to-peer context and future research can assess other team structures. For instance, work arrangements such as supervisor-subordinate or synchronous versus asynchronous [87] can also be investigated.

Technostress is another consideration that can be explored in future research [87]. Technostress includes techno-anxiety (e.g., uneasiness due to the unpredictable results during use), techno-addiction, and techno-strain (e.g., trepidations associated with novel technology usage) [87,92]. The metaverse may pose different technostress issues due to its richness in comparison to other technologies. For instance, technostress may manifest because the metaverse is a continuous, dynamic, virtual environment that "demands context switching" [87,p.115]. Future research can leverage the research model from this study to assess the potential of the flow experience in reducing technostress.

5. Conclusion

There is as much excitement as there are questions regarding the metaverse's ability to provide engaging experiences that result in satisfactory outcomes and its continued use. To capitalize on the technology's potential and ensure its productive use, it is essential to select an optimal configuration of human capital, such as individual versus collaborative, that will be most effective for utilitarian use of the metaverse [93]. Our findings suggest that online collaboration in the metaverse can facilitate a greater flow experience than completing the task alone, providing guidance for practitioners who desire to leverage the metaverse. Not only do individuals collaborating with others in the metaverse experience greater cognitive absorption than individuals completing the task alone, but this enhanced experience also leads to greater satisfaction with the task outcome as well as increased intention to use the technology. As the metaverse evolves and new methods of profiting from this innovative technology emerge, the extensiveness of its reach and impact can be augmented through strategic efforts surrounding its use and application.

CRediT authorship contribution statement

Fiona Fui-Hoon Nah: Writing – review & editing, Writing – original draft, Visualization, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Brenda Eschenbrenner:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Langtao Chen:** Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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