

SENSE OF AGENCY (SOA) IN HUMAN-HUMANOID TECHNOLOGY (HT) INTERACTIONS IN FLEXIBLE FACE-TO-FACE LEARNING DURING CHALLENGING TIMES: A MULTIMETHOD RESEARCH[†]

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†A funded project of the National Research Council of the Philippines

ABSTRACT

As technological advancement in higher education mainstreams humanoid technologies (HTs) in clinical simulations in medicine and allied health programs, the sense of agency (SoA) involved in human-computer interaction and associated experiences with HT use must be investigated. This study aims to develop and pilot a self-report measure of SoA and explore its connection with the demographic, behavioral intention for technology use, and performance variables among learners (n=456) in a flexible face-to-face learning program during the pandemic. A mixed-method exploratory sequential design was employed, beginning with empirical measurements and analyses (descriptive, comparative, modeling) followed by a qualitative descriptive inquiry via focus group discussions to capture student experiences and practical reasoning associated with HTs and other flexible learning activities. Quantitative results revealed an acceptable tool, demographic and performance differences in SoA measures, and a parsimonious model of SoA and related variables. Qualitative inquiry produces a model eidetic of student experiences and practical reasoning. This project reinforces a shift from technology-centered and human-centered design to a life-centered approach to technology and simulation development.

Keywords: *humanoid technologies, human-computer interaction, sense of agency, behavioral intention, flexible learning, structural equation modeling,*



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Published by the National Research Council of the Philippines

INTRODUCTION

Technological advancement in the educational sector has introduced the integration of Humanoid (human-resembling) Technologies (HTs) in mainstream healthcare education and research. Universities worldwide continuously invest in simulation laboratories with high-fidelity human patient simulators to mimic client conditions in real-world scenarios and provide an exciting solution to develop learner competencies (Bartlett et al., 2021; Southall & MacDonald, 2021). Then and now, researchers are also devoting substantial attention to studies exploring the utility of humanoid machines for health (Lau et al., 2020; Pennisi et al., 2016) and discovering the dynamics between professional (healthcare provider-HT) and interventional (patient-HT) interactions. In addition, HTs are increasingly recognized as an effective teaching tool in schools, especially during the COVID-19 pandemic, where clinical simulation is a core component of the on-campus flexible face-to-face learning experience.

Undoubtedly, the utilization of HTs will dominate the field of education during the pandemic and in the years to come as variants emerge and pose varying challenges and unpredictable limitations in on-clinical exposures. Scientific literature has shown that the use of HTs in healthcare education is directly linked with the nature of healthcare practice as distinctively personal, social, and interactional. For instance, healthcare providers must establish social rapport with their clients and other healthcare team members in practice situations. Simultaneously, the patient must exercise interpersonal skills with the healthcare workers for an effective client-provider helping relationship. Notably, the quality of healthcare outcomes is directly linked to the nature of the provider-patient relationship intersecting mutual trust, confidence, and a sense of security (Leslie & Lonneman, 2016).

With the advent of HTs in the healthcare sector, providers, patients, and students must also maintain interaction with technology like HTs.

HTs can elicit a more natural human front in human-computer interactions because users tend to anthropomorphize (Epley et al., 2007) and produce an intentional stance (Dennett, 1987) for human-resembling machines. As an exemplar, a recent exciting study (Stroessner & Benitez, 2019) has shown that participants respond more positively to humanoid than non-humanoid (e.g., task trainer) technologies. This scenario is also evident in educational spaces where novice entry-level learners initially undergo hospital simulations in virtual laboratories taking care of HPS instead of an actual human being for safer practice before hospital rotations. It has been discovered that the quality of hospital simulation in nursing and medical schools is also dependent on how humanoid (human-resembling) the simulation

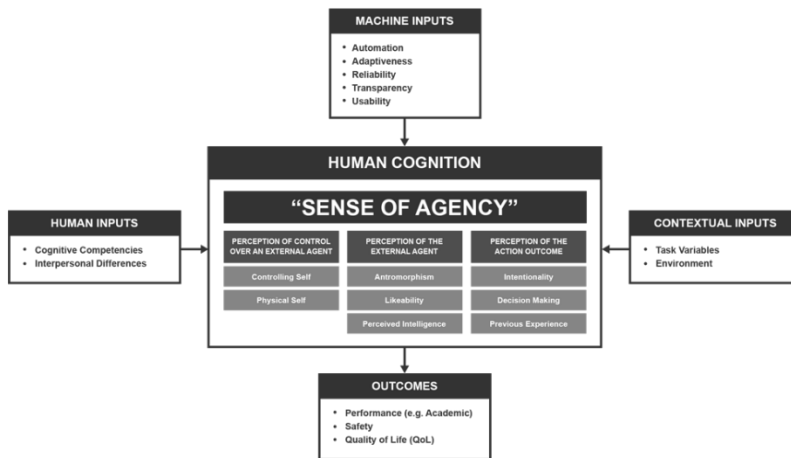
technologies are (Hamstra et al., 2014). The degree to which an HPS looks acts, and perceives like a human patient is an antecedent of teaching effectiveness.

Despite society's increasing acculturation to HTs and its apparent benefits reported in scientific studies, there are limited tools to understand the social cognitive process among technology users in human-HT interaction in healthcare education situations (Marchesi et al., 2019). HTs are expected to provide key players with information and stimulus to act accordingly in various positions. Therefore, it would be crucial to investigate how HT agents modify human action (Ciardo et al., 2018). This paper advances that perception with HTs directly relates to the quality of the learning experience that a student will achieve. It is also interesting to discover how HTs can shape one's perception of being in charge of the learning scenario and how a person perceives the machine's response as a consequence of one's action (Haggard, 2017; Shneiderman, 2004). This perception is collectively known in scientific literature as the sense of agency (SoA).

Establishing a measure for SoA and identifying its learning effects in HT-enabled flexible learning modality during the pandemic-stricken academic industry is a noble scientific activity with potential implications in the attainment of Sustainable Development Goal on Quality Education (SDG#4), healthcare field, considering the increasing demand for quality and safe practice in the technology-driven health industry. Furthermore, since SoA is a fundamental feature of a person's subjective and social experience (Engbert et al., 2008), its evaluation may potentially serve as a predictor of performance for students, healthcare personnel, and even clients in HCI (Figure 1). Therefore, it is essential to discover how SoA will serve as a determinant and predictor of effective instruction and how it compares with other performances.

Figure 1

Sense of Agency in Human-Computer Interaction Framework (Stowers et al., 2017)



The present study is anchored in the following objectives:

1. Develop a self-report measure of Sense of Agency (SoA) in human-humanoid technology interactions in flexible learning clinical simulation. Three (3) subsections of SoA will be developed and explored.
2. Assess and evaluate students' technology competency, demographic differences in their SoA, behavioral intention (BI), and performances in flexible learning simulation and immersion
3. Develop a parsimonious model to describe SoA, behavioral intention (BI), and performance variables.
4. Explore the student participants' experiences and practical reasoning tendencies in simulation, immersion, and combination modes in flexible learning to gather valuable insights into the utility of HTs.

METHODS

The study is a component of the assessment project of the flexible learning approach designed by the Our Lady of Fatima University (OLFU), tagged as the Fatima Learning Experience (FLEx). OLFU is a proponent of safe return to flexible face-to-face (F2F) instruction and was the first institution approved by the Commission on Higher Education (CHED) to hold F2F sessions. The institutional FLEx program and its mechanisms served as a benchmark to various higher education institutions through CHED, as shared in the media and numerous virtual events.

An essential arm of the FLEx learning approach is the use of HT-enabled high-fidelity clinical simulation using OLFU's clinical simulation lab at the newly built Research Innovation Science and Enterprise (RISE) Tower before the pandemic. The simulation hopes to generate a comparable clinical experience for students during challenging times.

This paper advances the development of items for the SoA metric involving three (3) juxtaposed measures of agency and its attributes. A mixed-method exploratory sequential design (Konapur et al., 2019; Salvador et al., 2020), a key component of tool and model development studies, was adopted. A robust framework was implemented to achieve the study aims (Mosquera et al., 2021) (Figure 3). Phase 1 involves steps in the development and standardization of the item pool, namely: (1.1) literature search and review, (1.2) blueprint development, (1.3) creation of measure items, and (1.4) content validity using expert review. Phase 2 encompasses psychometric analyses. Phase 3 involves using the validated tool to measure SoA and compare learning effects among students in nursing and medicine in simulation, immersion, and combination modes in flexible learning. Finally, phase 4 will qualitatively examine the participant experiences and generate themes.

Phase 1: Development and Standardization of Item Pool

Sense of agency is not a single construct (Grünbaum & Christensen, 2020) and requires a parallel assessment of various constructs. An extensive literature review was conducted to explore the concept of SoA (Figures 1–2) and review existing measures attached to its constructs. A blueprint was constructed to summarize the essential details and items for the Metric of Juxtaposed Sense of Agency (Table 1) or MJ-SoA. This paper defines MJ-SoA as the “perception of own subjective feeling of control and action-outcome towards humanoid technologies in human-computer interaction in healthcare situations.” Twenty-four (24) items with seven scales (1= totally disagree to 7= totally agree) were generated for the initial version of the MJ-SoA tool (Table 1).

Table 1

MJ-SoA Questionnaire Attributes

MJ-SoA Attribute	Theoretical Definition	Source(s)	Operational Definition	MJ-SoA Items
IA-PC Controlling Self	Judgment about action; Perception of whether the step is from a person or by an external agent	(Farrer et al., 2008; Synofzik et al., 2010)	Perceived level of autonomy over one's action	I have complete control of my actions I have free will to do what I want I act based on my intention
IA-PC Physical Self	Perceived sensorium	(Blakemore et al., 1998)	Perceived level of confidence in one's sensorimotor functions	I have good reflexes I am skillful I move gracefully
EA-PE Anthropomorphism	Perception of human-like appearance of external agents	(Epley et al., 2008; Swiderska & Küster, 2018)	The perceived appearance of HT	The HT looks human The HT seems conscious The HT behave naturally
EA-PE Likeability	Likeability of an external agent	(Ventre-Dominey et al., 2019)	Perceived level of desirability of HT	The HT looks friendly The HT seems kind The HT is appealing to eyes
EA-PE Perceived Intelligence	Perceived presence of artificially intelligent algorithm that responds independently of any expert human guidance	(Fiske et al., 2019)	Perceived level of HT's data processing capability	The HT is intelligent The HT is sensible The HT is competent
EA-PA Intentionality	Perception of the degree of how a person's action caused the outcome; Comparison between the expected result and actual state	(Chambon et al., 2015; Frith et al., 2000; Haggard & Chambon, 2012; Imaizumi & Tanno, 2019; J. Moore & Haggard, 2008; J. W. Moore, 2016)	Perception of the level of HT response	The HT act on my command The HT responds to my actions The HT provides feedback
EA-PA Decision making	The capacity of the robot to make purposeful action decision	(Barlas, 2019; van der Woerd & Haselager, 2019)	The level of HT independence to make decision	The HT can make its own decision The HT decides on his own The HT has an automatic response
EA-PA Previous experience	Previous experience with the robot	(Barlas, 2019)	Previous experience with HT	The encountered HTs before I have experience with HT I was exposed to HT in the past

Note. IA = individual agency; PC = perception of control; EA = external agency; PE = perception of the external agent; PA = perception of action-outcome.

Face and content validity was established through expert judgment to ascertain how the test items represent the test domains and estimate the degree to which the measure will tap the constructs that the tool aimed to assess (Salkind, 2010; Lewis-Beck et al., 2004). In addition, critical friends (Kember et al., 1997) in HCI were recruited for the Delphi technique (Lynn, 1986).

Phase 2: Psychometric Analyses

Construct validity (discriminant and convergent), or the “extent to which the test is shown to measure a theoretical construct” (Lewis-Beck et al., 2004), was established. The student participants were recruited from a nursing and medical school from an autonomous university in the Philippines with the inclusion criteria of being enrolled and exposed to clinical simulation using a high-fidelity human patient simulator (HT). After securing appropriate ethical clearance, the developed tool was administered to the participants.

Phase 3: Assessment of SoA

SoA and student performances were collected using the attributes of MJ-SoA and researcher-developed questionnaire. Descriptive statistics (Frequency and Percentage; Mean and Standard deviation) were used to express quantitative outcomes. Analysis of Variance (ANOVA) was employed to test significant differences on subjects’ MJ-SoA based on demographic attributes. Finally, Structural Equation Modeling was conducted to assess convergent validity, discriminant validity, reliability, and overall model structural estimates.

Phase 4: Qualitative Phase

A narrative descriptive qualitative design was employed to evaluate the experiences and practical reasoning in flexible learning experiences of the students.

Purposive sampling to identify “rich cases” from the results of the quantitative section of this project was employed. An expert-validated *aide-memoire* was constructed as an interview tool. Focus Group Discussions (FGD) were conducted via videoconferencing platform. Interview texts were transcribed, coded, and analyzed using MAXQDA® Analytics Pro (VERBI Software, Germany). Member checking procedure was conducted to ensure trustworthiness. Reflective notes or memos were created to accumulate ideas, concepts, and connections with quantitative data (Given, 2008).

RESULTS

Respondent Demographics, Technology Competency, Performances, and Sense of Agency (SoA)

As shown (Table 2), the majority of the respondents are female (77.40%) and within the 20-24 age bracket (73%). Almost three-quarters of the participants are nursing students (73.68%) and in their senior years (73.25%). Most of the respondents (70.60%) were exposed to both clinical simulation in laboratories and actual immersion in clinical affiliations.

Table 2

Respondents' Demographics (N=456)

Demographic Variable	n	%
Gender		
Male	103	22.60
Female	353	77.40
Age		
20-24	333	73.00
25-29	100	21.90
30-34	17	3.70
35 and older	6	1.30
Program		
Nursing	336	73.68
Medicine	120	26.32
Year Level		
Third Year	122	26.75
Fourth Year	334	73.25
Flexible Learning		
Simulation	134	29.40
Both	322	70.60

Table 3 depicts the self-rating of the subjects in various competency areas. Technology competence is mainly rated as “very good” (41.45%) and “excellent” (31.14%). Using a 5-point scaling approach, half of the participants (51.32%) rated their academic performance as “good”. Almost half (41.89) and one-third (32.46%) of the cohort assessed their simulation and immersion performances respectively as “very good”.

Table 3
Students’ Technology Competency and Performance (N=456)

Performances	Poor		Fair		Good		Very Good		Excellent	
	n	%	n	%	n	%	n	%	n	%
Technology	-	-	36	7.89	64	14.04	189	41.45	142	31.14
Academic	-	-	24	5.26	234	51.32	162	35.53	36	7.89
Simulation	2	0.44	24	5.26	174	38.16	191	41.89	65	14.25
Immersion	1	0.22	18	3.95	110	24.12	148	32.46	45	9.87

Table 4 shows the SoA measures of the participants. Individual agency attributes were rated as “very high” (Controlling: $M = 5.50$, $SD = 1.04$; Physical: $M = 5.38$, $SD = 0.91$). External agency on perception of external agent attributes were assessed as “high” (Intelligence: $M = 4.80$; $SD = 1.44$) to “very high” (Anthropomorphism: $M = 5.11$; $SD = 1.20$; Likeability: $M = 5.26$; $SD = 1.19$). External agency on perception of action outcome attributes were rated as the lowest but still within the “high” marks (Intentionality: $M = 4.80$; $SD = 1.44$; Decision: $M = 4.20$; $SD = 1.58$; Experience: $M = 4.70$; $SD = 1.71$). The participants rated their “behavioral intention” to use simulators in the future as “very high” ($M = 5.66$; $SD = 1.26$). All measures are considered reliable (Cronbach’s alpha > 0.82).

Table 4
Measure of Juxtaposed Sense of Agency (MJ-SoA) and Construct Reliability

Attributes	Mean	SD	Reliability
Individual agency (IA)			0.83
Controlling	5.50	1.04	
Physical	5.38	0.91	
External agency (EA): External agent			0.94
Anthropomorphism	5.11	1.20	
Likeability	5.26	1.19	
Intelligence	4.80	1.44	
External agency (EA): Action outcome			0.90
Intentionality	4.80	1.44	
Decision	4.20	1.58	
Experience	4.70	1.71	
Behavioral Intention	5.66	1.26	

Note. Extremely low = 1.00-1.99, very low = 2.00-2.99, low = 3.00-3.99, neither = 4.00-4.99, high = 5.00-5.99, very high = 6.00-6.99, extremely high = 7.00 and above.

Demographic Differences in Student Performance, MJ-SoA, and BI

Tables 5 and 6 show the demographic differences in student performances, MJ-SoA, and BI. Results revealed significant differences ($p < 0.05$) in academic and laboratory performances when grouped to age ($\chi^2 = 13.73$; 5.17) and program ($\chi^2 = 6.75$; 7.67). There were significant differences ($p < 0.05$) in likability across the board (t : sex = -2.25, age = 2.51; program = 2.02; level = -2.20; exposure = 2.01) and experience (t : age = 3.82, program = 5.71, level = -5.75, exposure = 6.56) except for sex ($t = -1.47$), which was a significant factor ($p < 0.05$) for physical ($t = -1.99$), anthropomorphism ($t = -2.06$), and likability ($t = -2.25$) attributes. Level and Exposure were significant factors affecting most SOA attributes: anthropomorphism ($t = -4.28$; 4.04), likability ($t = -2.20$; 2.01), intelligence ($t = -8.34$; 8.37), intentionality ($t = -8.34$; 8.37), decision ($t = -5.44$; 5.34), and experience ($t = -5.75$; 6.56). Age and program generated significant differences in likability ($t = 2.51$; 2.02) and experience ($t = 5.71$). Moreover, only these two factors significantly influenced behavioral Intentions ($p < 0.05$; $t = 5.52$; 6.38).

Table 5

Demographic Differences in Student Performances

Performances	Sex ^a	Age ^b	Program ^c	Level ^d	Exposure ^e
Technology	2.13	1.75	0.76	0.90	0.70
Academics	0.08	13.73*	6.75*	0.00	0.75
Immersion	0.02	1.70	3.58	-	-
Simulation	0.05	5.17*	7.67*	0.90	0.10

* $p < 0.05$.

^a Male = 103; Female = 353; $df = 1$.

^b < 25 years = 333; 25+ = 123; $df = 1$.

^c Nursing = 336; Medicine = 120; $df = 1$.

^d Year 3 = 122; Year 4 = 334; $df = 1$.

^e Combination = 134; Simulation = 322; $df = 1$.

Table 6
Demographic Differences in MJ-SoA and BI

Attributes	Sex ^a	Age ^b	Program ^c	Level ^d	Exposure ^e
MJ-SoA					
Controlling	-1.52	-0.84	-1.17	-1.18	1.57
Physical	-1.99*	-0.93	0.29	-1.24	1.50
Anthropomorphism	-2.06*	0.75	0.90	-4.28*	4.04*
Likability	-2.25*	2.51*	2.02*	-2.20*	2.01*
Intelligence	0.14	0.06	0.41	-8.34*	8.37*
Intentionality	0.14	0.06	0.41	-8.34*	8.37*
Decision	0.64	0.18	-0.16	-5.44*	5.34*
Experience	-1.47	3.82*	5.71*	-5.75*	6.56*
Behavioral Intention	-1.44	5.52*	6.38*	-0.80	1.36

* $p < 0.05$;
^a Male = 103; Female = 353; df = 454.
^b < 25 years = 333; 25+ =123; df = 454.
^c Nursing = 336; Medicine = 120; df = 454.
^d Year 3 = 122; Year 4 = 334; df = 454.
^e Combination = 134; Simulation = 322; df = 454.

Structural Equation Modeling

Structural equation modeling employing partial least squares (PLS-SEM) is typically analyzed and interpreted sequentially, in two stages, which involve the analysis of the measurement model followed by the study of the structural model (Amora et al., 2016; Amora, 2021). Analysis of the measurement model includes the assessment of convergent validity, discriminant validity, and reliability (Kock, 2014).

Convergent and Discriminant Validity

Thirty-two (32) questionnaire items representing six (6) study constructs related to MJ-SOA, behavioral intention for technology use, and technology, academic, simulation, and immersion performances were included in the modeling. Indicator loadings and average variance extracted values are depicted in Table 7, indicating satisfactory convergent validity. There is a strong convergent validity for both the indicators and constructs of the MJ-SoA, as evidenced by the average variance extracted (AVE) value of more than 0.50 (0.698). The model elements are considered valid since inter-construct correlations of on-diagonal elements are higher than the off-diagonal elements (Fornell & Larcker, 1981).

Table 7
Convergent Validity Statistics

Variables/indicators	MJ-SOA	Academics	Behavioral Intention	Technology	Simulation	Immersion	AVE
MJ-SOA							.698
Individual agency	.681	0.232	0.074	0.120	0.096	-0.137	
External agency: External agent	.913	-	0.004	-0.001	-0.058	0.055	
External agency: Action outcome	.893	-	0.092	-0.090	-0.014	0.048	
Academics	.000	1.000	.000	.000	.000	.000	1.00
Behavioral intention	.000	.000	1.000	.000	.000	.000	1.00
Technology	.000	.000	.000	1.000	.000	.000	1.00
Simulation	.000	.000	.000	.000	1.000	.000	1.00
Immersion	.000	.000	.000	.000	.000	1.000	1.00

Notes. The values in bold are called indicator loadings. All indicator loadings have $p < 0.05$. The other values are called cross-loadings. Each of the Technology, Simulation, Behavioral Intention, Academics, and Immersion is a one-item variable; hence, the indicator loading is 1.000.

Table 8
Discriminant Validity Statistics

	MJ-SOA	Academics	Behavioral Intention	Technology	Simulation	Immersion
MJ-SOA	0.836					
Academics	0.306	1.000				
Behavioral intention	0.446	0.162	1.000			
Technology	0.157	0.277	0.016	1.000		
Simulation	0.379	0.610	0.243	0.296	1.000	
Immersion	0.304	0.516	0.202	0.275	0.665	1.000

Notes. The values in the diagonal are square roots of the variable's AVEs, while the values below the diagonal are correlations among the variables. There is discriminant validity since the square roots of the AVEs are larger than the correlations (Fornell & Larcker, 1981).

Structural Estimates

The structural estimates of the parameters, shown in Figure 2 and Table 9, convey good model fit and consistent quality indices. Path analysis revealed that all direct and indirect effects coefficients are significant at 0.05. The data fit statistically with the model: $APC = 0.297, p < .000$; $ARS = 0.145, p < 0.003$; $AVIF = 1.049$ (with the ideal range); $AFVIF = 1.610$ (with the ideal range). Further, the Tenenhaus GoF is large (GoF) = 0.372. MJ-SOA is a significant predictor of simulation performance, behavioral intention, and academic performance. Interestingly, technology competency directly influences simulation performance, MJ-SoA, and academic performance and indirectly impacts simulation performance, behavioral intention, and academic performance through MJ-SoA. Concurrent with expectations, simulation and academic performance are significant predictors of immersion performance in the clinical area.

Figure 2
Model Fit, quality indices, and structural estimates

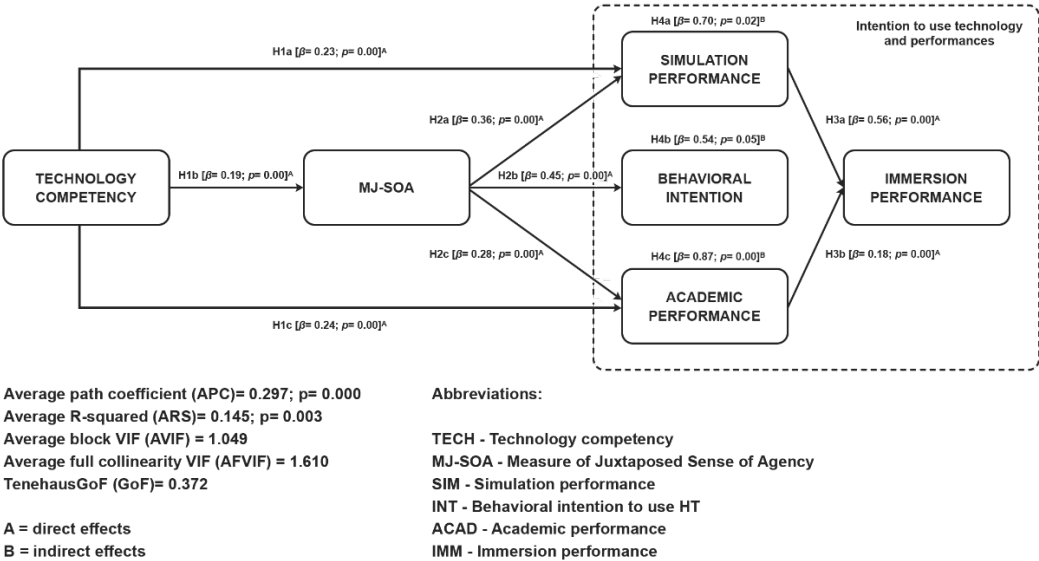


Table 9
Structural estimates

Paths	β	SE	p	f^2
Direct Effects				
H1a: TECH→SIM	.229	.045	.000	.070
H1b: TECH→MJ-SOA	.194	.045	.000	.038
H1c: TECH→ACAD	.238	.045	.000	.071
H2a: MJ-SOA→SIM	.360	.045	.000	.147
H2b: MJ-SOA→INT	.447	.044	.000	.200
H2c: MJ-SOA→ACAD	.276	.045	.000	.091
H3a: SIM→IMM	.558	.046	.000	.372
H3b: ACAD→IMM	.175	.044	.000	.091
Indirect Effects				
H4a: TECH→MJ-SOA→SIM	.070	.033	.017	.021
H4b: TECH→MJ-SOA→BI	.087	.033	.004	.001
H4c: TECH→MJ-SOA→ACAD	.054	.033	.052	.016

Note. β = Path coefficient; f^2 = effect size.

Qualitative Findings

Focus group discussions were also conducted to explore SoA and capture the flexible learning experiences of the students. Specifically, the students' practical reasoning about their immersion experiences was qualitatively investigated. Five focus group discussions (FGDs) of 4-6 members were conducted for nursing and medicine student groups. All our key informants are between the ages of 20-25 and in their senior years, with primarily female nursing students (Table 10).

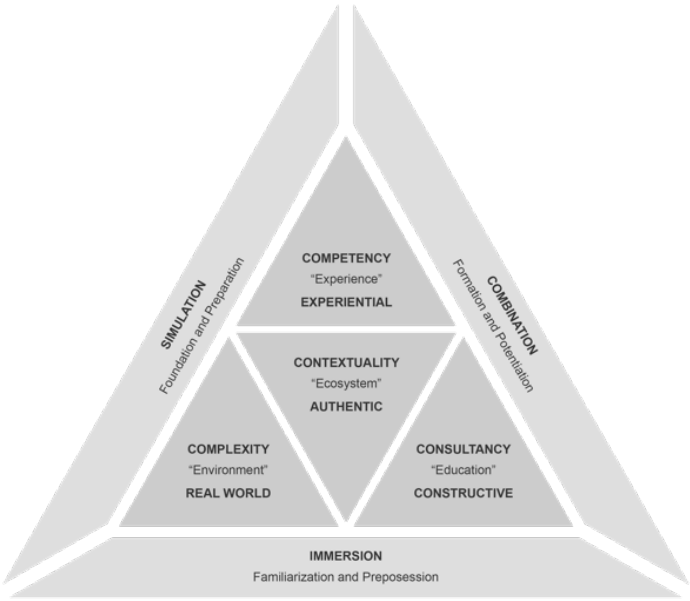
Table 10
Key Informants' Demographics

Demographic	FGD1		FGD 2		FGD 3		FGD 4		FGD 5	
	f	%	f	%	f	%	f	%	f	%
Gender										
Male	1	25	0	0	1	20	1	25	4	67
Female	3	75	5	100	4	80	3	75	2	33
Age: 20-25	4	100	5	100	5	100	4	100	6	100
Program										
Nursing	4	100	5	100	5	100	4	100	0	0
Medicine	0	0	0	0	0	0	0	0	6	100
Level: Senior	4	100	5	100	5	100	4	100	6	100

Note. FGD1 = 4; FGD2 = 5; FGD3 = 5; FGD4 = 4; FGD5 = 6.

Thematic analyses revealed interesting themes related to the affordances and dimensions of flexible learning experiences during the COVID-19 pandemic. The themes and sub-themes were summarized in the emerged simulacrum, the Practical Reasoning during Immersion and Simulation Model or PRISM (Figure 3), and a summary of significant Statements (Table 11).

Figure 3
Practical Reasoning during Immersion and Simulation Model (PRISM)



Note. PRISM depicts the Affordances, Bases, and Characteristics (ABCs) of Effective Flexible Learning during the Pandemic

Table 11*Summary of significant statements*

Concepts: ABCs of Flexible Learning	Theme/ Description	Significant Statements
<i>Affordances:</i> Learning environments	<i>Simulation</i> Laboratory-based	<p>"Good foundation in terms of building skills... gave us an idea on what to do in our hospital duties. The experience gave us a head start in assisting patients before exposure to hospitals." (S5A)</p> <p>"Practical and efficient. It allows us to have a training ground while keeping us safe" (S4B)</p> <p>"The mannequins are advanced" (S4A)</p>
	<i>Immersion</i> Work setting-based	<p>"Exposure to reality" (S1B)</p> <p>"I look forward to the hospital exposure because I think that is the only place where I can apply learning from theoretical." (S5C)</p>
	<i>Combination</i> Laboratory & work settings	<p>"Combination of hospital exposure and simulation laboratories is vital" (S4D)</p> <p>"There is a need to practice using mannequins first... it will provide us a first-hand experience and good foundation for clinical duty" (S3C)</p>
<i>Bases:</i> Learning principles in effective, flexible learning	<i>Contextuality</i> Case-driven	<p>"I am happy to examine clinical cases provided to us... It matches the case and materials provided in the virtual lab" (S2B)</p> <p>"Learning is specific to the field and subject... I appreciate the pregnancy scenarios" (S5B)</p>
	<i>Competency</i> Learning outcomes-driven	<p>"Flexible learning should focus on how to perform procedures and manage for our patients" (S1B)</p> <p>"It's all about the skills since we have enough of the theories in the subject" (S5A)</p>
	<i>Complexity</i> Technology-driven	<p>"Important for students to practice first using hi-tech mannequins who can mimic the responses and sounds produced by a real patient" (S3C)</p> <p>"Mannequins and simulators are helpful. Some of the mannequins can imitate the reactions and sounds of real-life patients" (S5B)</p>
<i>Characteristics:</i> Learning features of effective, flexible learning	<i>Consultancy</i> Mentoring-driven	<p>"We are thankful to our instructors who are always ready to assist us." (S3D)</p> <p>"I appreciate the guidance given by clinical instructors, especially in assisting during hospital procedures" (S4D)</p>
	<i>Real-world</i> Close to reality	<p>"Should prepare students by visualizing the actual scenarios so that in the future hospital exposures, they will be more confident in giving patient care" (S2B)</p> <p>"It should be close to the real world" (S2D)</p>
	<i>Authentic</i> Effective & research-based	<p>"The learning experiences are effective for me, I feel more confident, and I ace my exams" (S4D)</p> <p>"They also conduct surveys and inquire about our feedback... I think for study purposes" (S1B)</p>
	<i>Constructive</i> Organize and structured	<p>"The activities are related to one another... the lectures are linked with the activities in laboratory and hospital" (S1C)</p> <p>"I appreciate the checklist and rubrics... and they are organized" (S5B)</p>
	<i>Experiential</i> Activity driven	<p>"There are tasks... many tasks... and I appreciate them in addition to the lectures" (S2E)</p> <p>"I am looking forward to the next set of activity... makes learning unpredictable but exciting" (S3A)</p>

Learning environments during flexible learning programs are summarized in the “Affordances” central theme consisting of “simulation”, “combination”, and “both” as subthemes. The students expressed their perceptions of and reasons for actively participating in these activities and agreed that exposure to HTs during simulation is a vital prerequisite for clinical exposure in hospitals. They mentioned the core benefits of simulation, such as confidence-building, safe practice, and foundation training. Key informants preferred to be exposed to simulation before immersion than immersion alone. The theme “Bases” refers to the valuable principles in designing an effective, flexible learning program based on the learners' experiences. The theme highlights the importance of “context”, “competency”, “complexity,” and “consultancy” elements as subthemes.

Interestingly, the students described the “Characteristics” or features of effective, flexible learning. In all affordances, the learners mentioned their inclination to “real-world”, “authentic”, “constructive,” and “experiential” qualities of a flexible learning program during the pandemic. These themes revealed the value of a well-crafted, evidence-based, and well-thought program in offering teaching and learning experiences focusing on skills, competencies, and confidence as outcomes.

DISCUSSION

This study provided several insights relevant to understanding the learners, using HTs, and developing flexible learning programs. In addition, a mixed-method approach revealed answers to research aims advanced in the study. The profile of the student-respondents concurs with the current demographic features of Philippine learners consisting of primarily young adult females enrolled in medical and allied health programs (Commission on Higher Education, 2020), with nursing and medicine as top disciplines.

During the pandemic, developing the next generation of healthcare providers is essential to supply the local and global requirements of qualified and competent healthcare providers (Ortiga et al., 2022). Higher education institutions in the Philippines have adapted several proactive activities for the continuity of education despite national lockdowns (Joaquin et al., 2020) and negative reception and sentiments from several online pundits (Dayagbil et al., 2021). Although several regions in the country are having challenges with connectivity provisions (Salac & Kim, 2016), students consider their technological competency and literacy as the least challenging during the pandemic (Barrot et al., 2021). This outcome parallels the current study findings where the subjects rated themselves as “excellent” in technology-related competencies. Results in this area are promising since HTs

require competence in using technological devices and, at the same time, reinforce the need to ensure the ability to operate HT devices for both students and teachers during flexible face-to-face simulations. Moreover, technology support for university stakeholders during a pandemic is essential (Toquero, 2020) because it will strongly impact their satisfaction and perception of teaching and learning (Eycan & Ulupinar, 2021).

Demographic differences in the learners' MJ-SoA, behavioral intention (BI), and performances in flexible learning simulation, immersion, and the combination produced equally exciting results. Younger and nursing students were discovered to have significantly higher behavioral intentions to use HTs. This outcome communicates the generational divide in technology use and the need for more clinical immersion among senior students. It was also found that age and program were significant factors affecting student performances in academics and simulation. These findings communicate the potential differences in curricular content and maturity of learners. It was reported in a previous work that younger learners were more negatively impacted by the pandemic than their older counterparts (Toquero, 2020). Also, as expected, perception of SoA attributes when grouped according to age and during simulation, activities were significantly different. This result shows that the senior learners, with more prior exposure to the laboratory, have acknowledged the unique features of HTs as learning objects that directly respond to their interventions. Impliedly, students recognize their interactions with HTs during simulations as a re-enactment of a clinical scenario found in the actual world. This outcome confirms the propositions of the Uncanny Valley Theory (Mori et al., 2012), where realism positively impacts HT interaction and use (Betriana et al., 2021; Dino et al., 2022).

It was suggested that patient simulators like HTs must be more capable of generating life-like anatomy (Schebesta et al., 2011) and physiology of living persons (Geršak et al., 2021), rather than show interactional or conversation features, which is more feasible using “actor” patients (Wallace et al., 2010). Additionally, the anthropomorphism of HTs is an added feature for students to perceive the machine as “representative” of the actual patient. This perception may also be the reason why high fidelity HTs in teaching clinical procedures successfully mimic the actual procedure duration based on published outcomes of real-world patients (Wallace et al., 2010). Similarly, in a study that uses 3D HTs (Kleinert et al., 2016), an HT patient's visual appearance effectively motivates and engages the students in the lesson. Overall, the result in this area conveys the importance of human-like physiology and physical features, which altogether elicits a better measure of SoA among the student learners.

Modeling revealed that MJ-SoA directly influences simulation performance, academic performance, and behavioral intention for technology use. Also, technology competency directly impacts MJ-SoA, simulation performance, and academic performance. These outcomes also implied the presence of students' conscious awareness and ownership of their action that produces potential consequences (HT behavior) and outputs (e.g., academic performance). Specifically, in interaction with HTs, current findings refute previous claims that individual SoA might be impaired when individuals interact with artificial systems such as HTs (Barlas, 2019; Grynszpan et al., 2019). The presence of clinical instructors who co-direct the simulation activity might explain results in this area, with HTs only functioning as tools and models for effective instruction. The guidance of instructors is important. There is a need to emphasize instructor presence and mentorship in achieving higher order thinking skills regardless of teaching modality. This instructional component is important in the case of similar pandemic incident in the future.

Qualitatively, the study's outcomes have been extended to uncover the affordances, bases, and characteristics of effective teaching and learning within a flexible educational program during the pandemic. Focus group discussions emphasized learners' "practical reasoning," which is vital in elucidating individual reasoning, reflection, goals, and motivations in engaging in various activities and practices (R. J. Wallace, 2015). In this paper, the students expressed their intention to be immersed in simulation with HTs before clinical immersion. This finding concurs with prior research mentioning that students receiving simulation with HTs are more satisfied (Beyer, 2012) and have greater knowledge acquisition and confidence during actual practice on-site (Mulyadi et al., 2021). Like the outcomes of this study, previous work in the field attributed the success of HT use to the structure, quality, and fit of instructional simulation scenarios to the capabilities of HT (Ali et al., 2010). Therefore, curriculum planners must design the simulation incorporating signature pedagogies (Esterhazy et al., 2021; Shulman, 2005) reflective of medicine and allied health professions. The quality and quantity of teacher guidance were also expressed as relevant by the key informants encouraging instructors to embrace continuous training in supervision and scaffolding activities. Results in this section further concretizes the need to align teaching-learning-assessment activities to instructional intended learning outcomes that are student-centered and industry-driven.

CONCLUSION

The reliance on clinical simulation of nursing and medicine, as professions requiring a great deal of therapeutic interpersonal interactions with healthcare clients, has inevitably introduced HTs in training and honing its future professionals. As such, the

human-computer and human-humanoid interaction fields are relevant in examining concepts and phenomena in technology-driven flexible learning activities. In this study, SoA was affirmed to be a useful measure to consider in designing simulation activities with HTs during challenging times. It is advantageous in identifying the realism in clinical simulation and the students' control of the HT patient during learning scenarios. Generally, results communicate that simulation with HTs cannot replace the actual clinical immersion of the students but is considered a crucial component in the delivery of flexible teaching and learning activities. Exposure to simulation before immersion is preferred over outright experience in immersion alone due to the knowledge and confidence-building benefits of simulation with HTs. In designing effective, flexible learning programs that blend onsite and offsite activities, the PRISM diagram is a helpful tool to identify critical areas that need attention to ensure teaching and learning success with HTs and beyond.

This work produces and pilots a reliable tool to measure the SoA metric in HT interactions in educational settings. The instrument may examine the learners' stance in simulation activities that will eventually impact academic, simulation, and immersion performances. As discovered previously, higher SoA means a heightened sense of responsibility (Ciardo et al., 2020). MJ-SoA can also be used as an indicator of simulation realism and the effectiveness of HT response to student users. The current study promises to provide an additional valuable metric in examining technologies and SoA of users in the learning sector, both physical and cyberspace. Creative and interesting future studies may focus on testing mixed and augmented reality applications and remote simulations that utilize non-physical humanoids in virtual spaces.

The study also revealed classic and emerging technology teaching and learning insights. On the one hand, philosophies and attributes of quality flexible educational programs are still pertinent with or without a pandemic (e.g., scaffolding). Academicians in the medical and allied health field must stick to the best, proven, and evidence-based approaches based on their unique experiences. On the other hand, the study introduces the high outcome potentials of the life-centered approach (Borthwick et al., 2022) in developing simulators and simulation experiences in health education beyond the traditional technology or human-centered approaches. A life-centered design centers on responsible innovation by synergizing technology, viability, environment, and ethics (Borthwick et al., 2022). These design components received growing interest among scholars during the pandemic for their more sustainable and enduring impact on the people and the planet.

ACKNOWLEDGMENT

This study was funded by the National Research Council of the Philippines (NRCP) through the “Kapakanan ng Tao sa Oras ng Pandemya” (advancing human welfare at the time of a pandemic, KTOP) program.

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