

MEASURING THE IMPACT OF AI SOCIAL AGENTS ON BELONGING IN LEARNING COMMUNITIES

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Abstract

Online learning provides flexibility and accessibility, but creating a sense of belonging (SOB) and connectedness continues to be a challenge. This study investigates the potential of an AI-powered social agent, Social Agent Mediated Interactions (SAMI), to address challenges in fostering inclusivity in online learning. It investigates how learners' motivation to engage with AI tools is shaped by their need to belong (NTB), self-efficacy (SE), and personality traits. By analyzing the interactions between these factors and AI adoption, we aim to assess how SAMI can be adapted to diverse learner profiles, promoting more inclusive and supportive online learning experiences. No significant differences in the SE or NTB were observed between users of SAMI and non-SAMI adopters. However, our findings suggest that SAMI has the potential to enhance learners' SOB and community in online environments.

Keywords: AI social agents, Community of Inquiry, social presence, social interaction, online learning, personality traits.

1 INTRODUCTION

Online education is expanding rapidly, creating new challenges and opportunities for enhancing student engagement and sense of community. Online learners often face a unique set of barriers to social interaction and engagement, which are particularly pronounced in large, asynchronous classes where learners are geographically dispersed [5]. This lack of social integration can negatively impact students' cognitive engagement, motivation, and overall emotional well-being, potentially affecting their desire to complete their studies [5].

We explore the impact of SAMI, a novel AI-based intervention designed to enhance students' SOB and community in online learning environments. SAMI is an AI agent developed for use in class discussion forums [9]. SAMI recommends connections based on information provided in learners' self-introductions, created at the beginning of the semester in a designated thread on the online discussion forum for the class. These introductions include details such as hobbies and location, which enables the matching process, as shown in Fig. 1. SAMI extracts relevant details from self-introduction post and provides personalized recommendations. Our research focuses on SAMI's deployment at Georgia Institute of Technology's online Knowledge-Based Artificial Intelligence (KBAI) course across multiple semesters. Specifically, we investigate whether SAMI can cultivate a stronger SOB and engagement among learners and whether certain demographic or personality factors influence their adoption and experience of SAMI.

We anticipate a life cycle where NTB serves as the motivation, a SOB as the outcome, and SE as an influencing factor. We expect the motivation to use social agents and seek belonging within course settings can arise from factors beyond NTB and SE, potentially driven by personality traits. Our study examines several key dimensions:

- SOB: Does the implementation of SAMI promote a stronger sense of belonging among learners enrolled in the online KBAI course?
- NTB: Do learners who score higher on NTB choose to use SAMI? How does NTB influence a learner's intention to engage with SAMI?
- SE: Are there measurable differences in self-efficacy between students who utilize SAMI and those who do not?
- Big Five personality traits: How does personality impact learner's motivation to engage with AI-tools?

We also consider learner demographics in the context of:

- Equity in Adoption: Is there a disparity in learner adoption and motivations of SAMI based on their demographic characteristics?

By examining these factors, we aim to understand SAMI's role in fostering community, supporting learning, and potentially mitigating feelings of isolation in online education.

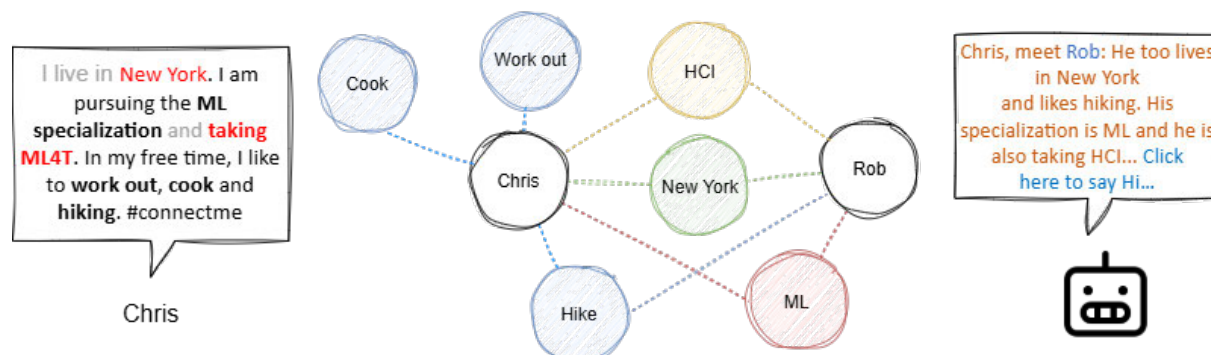


Figure 1. SAMI uses students' self-introductions to connect them based on commonalities. Adapted from Kakar et al. 2024.

1.1 Background

This study examines SAMI's effectiveness in fostering belonging and explores potential equity implications, including the gender gap in online social engagement. By addressing both social and equity aspects, this research fills a gap in the current literature. Additionally, we aim to use the findings to identify the opportunities to customize SAMI for various learner profiles, promoting a more inclusive and supportive online learning environment. We hypothesize that students with a strong NTB who follow SAMI's recommendations are likely to experience an enhanced sense of belonging, potentially leading to increased connectedness. Furthermore, we explore the role of SE in influencing the likelihood of following SAMI-recommended connections and actively seeking new connections.

Personality traits can be correlated with values that motivate specific actions. According to Roccas et al. (2002), extraversion and conscientiousness are positively correlated with achievement, openness is positively correlated with self-direction, and agreeableness is positively correlated with benevolence.

1.1.1 Sense of Belonging

Online learning environments, while lacking the physical proximity and direct interaction of in-person settings [13], can still foster social connectedness, community, and a sense of belonging [13], [23]. A strong sense of belonging enhances connection, reduces feelings of isolation, and improves satisfaction [18]. However, research indicates a gender gap in online social engagement, with men more likely to initiate non-anonymous social interactions [8]. This underscores the importance of developing interventions that promote a sense of belonging and encourage equitable participation among all learners.

Previous research indicates that Virtual Teaching Assistants (VTAs) have the potential to enhance teaching presence and contribute to addressing retention and engagement challenges commonly associated with large-scale online learning [12]. The current work continues the investigation into the impact of SAMI on social presence.

1.1.2 Need to Belong

NTB is defined as a fundamental human motivation to form and maintain enduring interpersonal relationships and connections [2]. This psychological construct highlights an intrinsic drive to engage in social interactions that foster belongingness. According to Baumeister and Leary (1995), individuals are motivated to participate in goal-directed activities to satisfy this need.

Research by Ardi and Maison (2014) suggests that individuals with a higher NTB exhibit increased online self-disclosure, reflecting a heightened effort to forge connections in virtual environments. This phenomenon is particularly relevant in the context of online learning, where the absence of physical presence may amplify the need for digital interaction to fulfil social belonging. Moreover, studies indicate

that fulfilling the NTB is linked to improved psychological well-being and academic performance, emphasizing its critical role in educational settings [14], [22].

1.1.3 Self-Efficacy

SE is defined as the individual's judgment of their ability to accomplish a task and their confidence in their skills to perform that task successfully [16]. This psychological construct plays a crucial role in determining how people approach goals, tasks, and challenges. Individuals with high SE are more likely to embrace difficult tasks as challenges to be mastered rather than as threats to be avoided, influencing their motivation and perseverance.

The research indicates that students enrolled in the online AI course exhibit self-regulation and high SE, which likely reflects positive cognitive engagement with the material [10]. Student SE can be enhanced through active interaction with educational materials and cognitive engagement [10].

1.1.4 Demographic Disparities in Online Learning

Research suggests that the demographics of online learning differ from traditional campus-based programs [20]. According to Joyner et al. (2022), online learners tend to be older, more geographically diverse, and possess varied educational backgrounds compared to their on-campus peers. These programs also attract a slightly higher proportion of underrepresented minorities, though they report a lower enrolment rate for women in online CS programs, emphasizing the need for targeted interventions. Additionally, underrepresented minorities were identified as another group requiring focused attention.

These demographic disparities highlight the need to investigate the role of AI-supported tools in fostering a SOB and promoting equity in online learning. Social agents show potential for improving online learning experiences. However, research on their effectiveness in enhancing a SOB, especially among diverse learner populations, remains limited.

2 METHODOLOGY

2.1 Study design

The participants in our study were students enrolled in an online graduate course, Knowledge-Based Artificial Intelligence (KBAI), offered during the Fall 2023, Spring 2024, Summer 2024, and Fall 2024 semesters.

SOB was measured in Fall 2023, Spring 2024, and Fall 2024. Table 1 illustrates the distribution of participants by gender and age. Since the division by age was chosen to create groups of approximately equal size, this would not be the case if we divided the group into adults and non-adults. In Fall 2023 and Spring 2024, students had access to a second AI agent designed to enhance teaching presence, the Virtual Teaching Assistant, called Jill Watson [12]. To exclude the impact of Jill Watson, we also describe the Fall 2024 dataset with only SAMI deployed.

NTB, SE, and Big Five personality traits were measured in the Summer and Fall of 2024.

2.1.1 Sense of Belonging

Community of Inquiry (Col) is a commonly used framework to measure social presence in online learning environments. The social presence sub-scale contains various dimensions, including affective expression, open communication, and group cohesion. Social presence questions aim to measure feelings of comfort and belonging within the course, their ability to connect with fellow participants, and their perception of online communication as a platform for social interaction [21].

Col survey [21] was administered to KBAI class learners (Fall 2023, Spring 2024 and Fall 2024) to assess their SOB. Question 14 specifically targeted this, asking: 'Getting to know other course participants gave me a sense of belonging in the course'. We mapped them to a 1-5 Likert scale (Strongly Disagree = 1, Strongly Agree = 5) for analysis. Scores on question 14 were assigned a corresponding value on the 1-5 scale. The Col survey had two additional questions 'I used SAMI' and 'I used Jill Watson'.

For Fall 2024, we had access to Mid-Course Survey distributed by the instructor. Mid-Course Survey was the component of the class independently of our work. This survey included all questions from the Social Presence section of the Col framework.

A one-tailed Welch's t-test was conducted to determine if the average SOB score was statistically higher for the treatment group (using SAMI) compared to the control group (not using SAMI). We conducted a Mann-Whitney U test as well because we are not assuming a normal distribution of the data.

2.1.2 Need to Belong Scale

In the Summer 2024 and Fall 2024 semesters, students were independently administered a validated NTB survey [11], separate from the Col survey. Leary et al. (2013) reported high internal consistency for the scale (Cronbach's alpha > 0.80), which is supported by previous research, reinforcing that the items measure the underlying construct. The scale was selected due to its extensive presence in literature, authors initially introduced the concept of NTB.

The NTB scale, consisting of 10 items, was adapted from the paper by Leary et al. (2013). Students were asked to indicate the degree to which each statement was true or characteristic of them, using the following 5-point Likert scale: 1 = Not at all, 2 = Slightly, 3 = Moderately, 4 = Very, and 5 = Extremely.

A one-tailed Welch's t-test and Mann-Whitney U test were conducted to determine if the average NTB score was statistically higher for the treatment group (using SAMI) compared to the control group (not using SAMI).

Table 1. Sense of Belonging Participant Gender and Age Breakdown by Semester and Group.

Semester	Group	Male	Female	Age ≤ 27	Age 27–32	Age ≥ 32
Fall 2023	Treatment (SAMI)	36	11	16	12	18
	Control	207	80	131	73	83
	Total	243	91	147	85	101
Spring 2024	Treatment (SAMI)	98	26	36	30	33
	Control	149	47	71	42	51
	Total	247	73	107	72	84
Fall 2024	Treatment (SAMI)	65	19	49	15	20
	Control	258	77	164	72	99
	Total	323	96	213	87	119

2.1.3 Self-Efficacy

During the Summer 2024 and Fall 2024 semesters, students were also given the Self-Efficacy for Learning and Performance Scale. This scale was presented in the paper A Manual for the Use of the Motivated Strategies for Learning Questionnaire [16]. Pintrich et al. (1993) reported a Cronbach's alpha of 0.93 for the self-efficacy subscale, indicating high internal consistency. The scale was selected due it presents in the previous research referenced in this work.

The sub-scale Self-Efficacy for Learning and Performance included 8 questions, which could be ranked on a 7-point Likert scale, ranging from 1 = Not at all true of me to 7 = Very true of me. To ensure consistency with the NTB scale, the middle option was labeled as 4 = Moderately true of me.

2.1.4 Personality

A personality survey was administered separately as part of another study using a standardized survey for the Big Five personality traits. The BFI-44 questionnaire introduced by John and Srivastava (1999) was used. The BFI-44 demonstrates high internal consistency, with Cronbach's alpha coefficients typically exceeding 0.80 for each of the five scales [7]. This indicates that the items within each scale measure underlying construct.

2.2 Data Collection

2.2.1 *Sense of Belonging*

For the Fall 2023 scores from the SAMI user group (treatment group — 47 learners) were compared to those who didn't use SAMI (control group — 287 learners). The treatment group is defined as students who answered 'I used SAMI' question in Col survey.

For Spring 2024, two definitions of the treatment group were considered. One defines the treatment group as students who created an introduction post with #connectme, resulting in 124 students in the treatment group and 196 in the control group. Alternatively, using the response to the 'I used SAMI' question in Col yielded smaller treatment and control groups. The definition with the larger sample size was ultimately chosen.

For Fall 2024, we defined the treatment group as students who created an introduction post with the hashtag #connectme, completed the Mid-Survey that included Social Presence questions from the Col framework, consent to data usage, and whose demographic data were available. The treatment group consists of 84 students, while the control group consists of 335 students. Col was introduced to the students at the end of the Fall 2024 semester as well, however, far fewer students responded to the survey. The treatment group consists of 39 students, while the control group consists of 187 students. Following the rule of selecting the larger sample size whenever possible, the analysis is based on Mid-Survey data, with end-of-semester data mentioned contextually.

2.2.2 *Need to Belong*

For Summer 2024, 58 students completed the NTB survey and agreed to data usage. The treatment group is defined as those students for whom NTB results are available and who created an introduction post with the hashtag #connectme, totaling 26 students. The control group consists of 32 students.

For Fall 2024, 256 students completed the NTB survey and agreed to data usage. The treatment group is defined as those students for whom NTB results are available and who created an introduction post with the hashtag #connectme, totaling 56 students. The control group consists of 200 students.

2.2.3 *Self-Efficacy*

For Summer 2024 and Fall 2024, the SE survey was administered simultaneously with the NTB survey. For Summer 2024 the treatment group is defined as those students for whom SE results are available and who created an introduction post with the hashtag #connectme, totaling 26 students. The control group consists of 32 students.

For Fall 2024 the treatment group is defined as those students for whom SE results are available, who consent to data usage, and who created an introduction post with the hashtag #connectme, totaling 56 students. The control group consists of 200 students.

2.2.4 *Personality*

For Summer 2024, a common subset of personality, NTB and SE surveys included 58 learners. In total 66 students filled out the Personality survey and agreed to data usage.

For Fall 2024, a common subset with NTB and SE surveys was 51 SAMI adopters and 181 non-adopters. Considering consent, we had 253 non-SAMI users, and 73 SAMI users replies to the Personality survey.

3 RESULTS

3.1 SAMI Adoption

We found no significant association between learner demographics and SAMI opt-in. Chi-square tests revealed no significant association ($p > 0.05$) between learner demographics (race, ethnicity, gender, age) and SAMI opt-in. This means that there was no statistically significant connection between these demographic factors and a learner's decision to use SAMI. Hence, the data suggests there is no bias in learners' adoption of SAMI (decision to opt in) across various demographics, promoting an equitable environment where all learners feel comfortable using the tool.

3.2 Sense of Belonging

3.2.1 Fall 2023

The treatment group had a statistically significant increase in SOB compared to the control group. The average score for the treatment group (using SAMI, $n=47$) was 3.96 (with standard deviation of 0.88), compared to 3.53 for the control group (not using SAMI, $n=287$, with standard deviation of 1.03). The one-tailed Welch's t -test produced a p -value of 0.002, which is less than the commonly used significance level of 0.05. This result suggests that SAMI use is associated with a stronger SOB within the online learning environment. Table 2 presents the p -value across the semesters produced by the Mann-Whitney one-tailed U -test for comparison, in the Fall 2023 the result was 0.006.

3.2.2 Spring 2024

The treatment group, (students using SAMI, $n=124$), achieved an average score of 3.67 (with standard deviation of 0.98), whereas the control group, (students not using SAMI, $n=196$), scored 3.39 on average (with standard deviation of 1.02). Following a one-tailed Welch's t -test, the calculated p -value was 0.007, falling below the conventional significance threshold of 0.05. Fig. 2 shows the distribution by age and gender, based on available records.

3.2.3 Fall 2024

In the middle of Fall 2024 semester the treatment group, (students using SAMI, $n=84$), achieved an average score of 3.34 (with standard deviation of 0.91), whereas the control group, (students not using SAMI, $n=335$), scored 3.18 on average (with standard deviation of 0.92). Following a one-tailed Welch's t -test, the calculated p -value was 0.08, above the conventional significance threshold of 0.05.

As contextual information from the end of the Fall 2024 semester, the treatment group (students using SAMI, $n = 39$) achieved an average score of 3.89 (standard deviation = 0.85), whereas the control group (students not using SAMI, $n = 197$) scored an average of 3.45 (standard deviation = 1.02). A one-tailed Welch's t -test yielded a p -value of 0.003, while a one-tailed Mann-Whitney U -test produced a p -value of 0.004.

We observe a greater SOB among SAMI users when grouping students by gender, with a similar pattern emerging when grouping by age, as shown in Fig. 2. These promising findings highlight SAMI's potential to bridge social gaps and enhance a SOB in online learning environments. However, further research is necessary to explore the long-term effects of SAMI on learner engagement and learning outcomes. Future studies could investigate the specific mechanisms of action within SAMI that contribute to a SOB and explore the potential for adaptation across different online learning contexts.

Table 2. Belonging average scores and p -values for the treatment and control groups across semesters.

Semester	Group	n	Avg	Std	p -val
Fall 2023	Treatment (SAMI)	47	3.96	0.88	0.006
	Control	287	3.53	1.03	
Spring 2024	Treatment (SAMI)	124	3.67	0.98	0.007
	Control	196	3.39	1.02	
Fall 2024	Treatment (SAMI)	84	3.34	0.91	0.061
	Control	335	3.18	0.92	

3.3 Self-Efficacy and Need to Belong

For SE and NTB in Summer we had a sample of 26 SAMI adopters and 32 non-adopters, where in Fall we had 56 adopters and 200 non-adopters.

Despite the initial expectations, we did not observe a statistically significant difference in SE, neither in the Summer or Fall semester between SAMI and non-SAMI users. SE scores were slightly higher for the treatment group in Summer, but almost the same in Fall. Differences were not statistically significant ($p = 0.36$ and $p = 0.64$, respectively).

Contrary to our expectations, neither the Welch's t -test nor the Mann-Whitney U -test ($p = 0.32$ for Summer, $p = 0.31$ for Fall) revealed a statistically significant difference in the NTB between SAMI non-

SAMI users. NTB scores were slightly higher for the treatment group in both semesters, but not statistically significant.

The table 3 presents average scores for two groups - Treatment (SAMI) and Control, across two semesters on two measures: NTB and SE. For each group, the number of participants (n), average scores (Avg), standard deviations (Std), and p-values produced by the Mann-Whitney one-tailed U-test for group comparisons are reported.

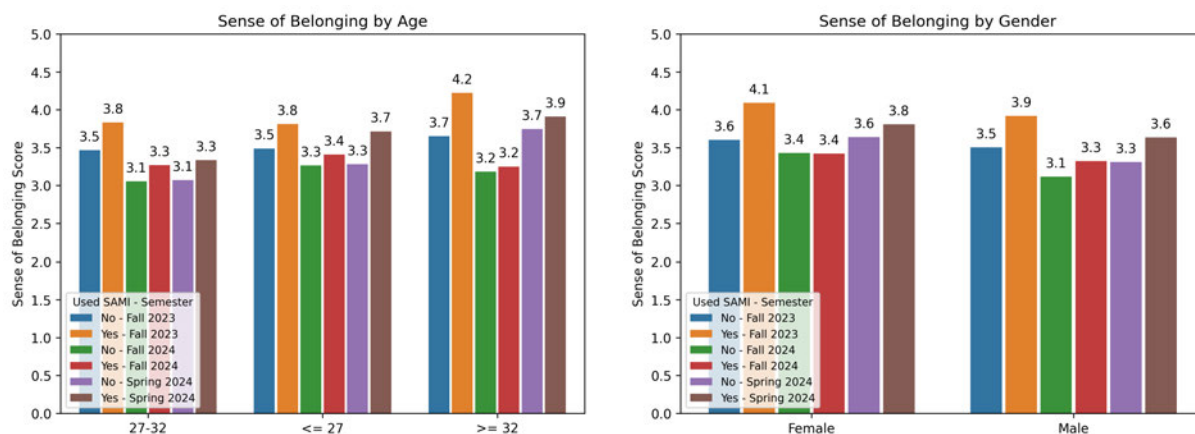


Figure 2. Fall 2024, Spring 2024 and Fall 2023 by (a), Age (b) Gender.

Table 3. NTB and SE average scores and p-values for the treatment and control groups across semesters.

Semester	Group	n	Avg (NTB)	Std	p-val	Avg (SE)	Std	p-val
Summer 2024	Treatment (SAMI)	26	30.00	7.00	0.32	41.73	8.54	0.36
	Control	32	29.31	6.98		40.43	8.39	
		Total	58					
Fall 2024	Treatment (SAMI)	56	30.01	6.65	0.31	41.21	8.50	0.64
	Control	200	29.42	6.39		41.28	8.96	
		Total	256					

3.4 Correlations Between Variables

In our study, we found statistically significant correlations between NTB and both Extraversion and Neuroticism, aligning with previous research by Leary et al. (2013). The correlation between NTB and Extraversion suggests that social acceptance requires a certain degree of sociability [11]. Additionally, we observed a correlation between NTB and Neuroticism, indicating that individuals high in Neuroticism tend to respond more strongly to indications that they are inadequately accepted [11].

In the Summer 2024 dataset, we observed that choosing SAMI correlates with Conscientiousness. This pattern did not reappear in Fall 2024, which could be due to the number of data points or differences in group characteristics. However, we have seen a moderate positive correlation between SE and Conscientiousness and Openness. Conscientiousness, one of the Big Five personality traits, is characterized by traits such as organization, self-discipline, and a strong sense of responsibility [15]. Individuals high in conscientiousness tend to be reliable, goal-oriented, and focused on long-term achievements [15]. This trait can also motivate them to adopt AI tools offered in education, it aligns with their preference for structure and productivity. AI technologies can help them meet their goals more effectively.

Contrary to expectations from the literature, no statistically significant negative correlation between NTB and SE was observed in the Summer dataset. However, in the Fall 2024 dataset, a statistically significant ($p = 0.008$) but weak negative correlation (correlation = -0.163) between NTB and SE was identified. Table 4 presents the correlation and p-value if it was at a significant or close to a significant level.

Table 4. Pearson Correlations between Variables for Summer and Fall of 2024

Variables	Conscientiousness	Extraversion	Neuroticism	Agreeableness	Openness
<i>Summer 2024</i>					
Used SAMI	0.351(p=0.007)	—	—	—	—
NTB	—	0.287(p=0.028)	0.311(p=0.017)	—	—
SE	0.228(p=0.08)	—	—	0.245(p=0.063)	—
<i>Fall 2024</i>					
Used SAMI	0.073(p=0.186)	—	—	—	—
NTB	—	0.135 (p=0.039)	0.278(p=0.000)	—	—
SE	0.304(p=0.000)	0.152(p=0.020)	-0.259(p=0.000)	0.159(p=0.015)	0.381(p=0.000)

3.5 Discussion

Learning thrives in social contexts, as collaboration fosters engagement and enhances understanding. When people work in supportive groups or teams, they can share diverse perspectives, clarify ideas through discussion, and solve problems collectively [3]. This interaction encourages active learning and can deepen comprehension by allowing learners to teach each other, provided they are invested and supported, this mutual engagement reinforces knowledge. A question arises: how can learning environments be continuously encouraging in a deterministic way, with support from AI, especially given that learners approach the process differently and find different aspects challenging? The following key findings highlight the impact of SAMI on various psychological and personality factors among learners:

- SOB: Learners who interacted with SAMI reported a statistically significant increase in sense of belonging compared to a control group. This suggests SAMI's effectiveness in fostering a more inclusive online learning environment. The results are conclusive in the Fall 2023 and Spring 2024 datasets, and less conclusive in the Fall 2024 dataset.
- NTB: Contrary to our expectations, we found no statistically significant difference in NTB between users of SAMI and those who do not use SAMI.
- SE: Our analysis revealed that there was no statistically significant difference in SE levels between SAMI users and non-SAMI users.
- Big Five personality traits: Among learners, SAMI is most popular among students whose personality is characterized by Conscientiousness in the Summer of 2024. This result was not repeated in the Fall of 2024.
- Learner demographics (race, ethnicity, gender, age) didn't affect their decision to use SAMI as no significant association was found. This indicates equitable access for diverse student populations.

Research shows that individuals with higher SE are more likely to adopt AI technologies, as they tend to perceive these tools as easier to use [4], [6]. However, in our case, the difference in SE between SAMI adopters and non-adopters may not be apparent, as the baseline population is already tech-savvy due to the study's context. Another possible explanation is that ease of use might not be the primary factor influencing the decision to use SAMI. Instead, SE may have a stronger correlation with the use of alternative support resources, such as class discussion forums [4].

The lack of a significant difference in NTB among students engaging with SAMI indicates that motivation for social interaction in these settings may not be primarily driven by NTB. For instance, some people may enjoy social engagement without necessarily seeking validation or acceptance [11]. Individuals may engage in social interactions for various reasons beyond NTB, such as shared goals, proximity or social exchange [11].

Many online master's students tend to be older and more experienced professionals compared to on-campus students. Their interactions with peers may be more goal-oriented, focusing on academic collaboration or networking rather than fulfilling need to belonging. For these students, peer interaction may be seen as an opportunity to expand their professional network or achieve specific academic objectives, rather than a way to satisfy a need for close social connections. This professional orientation might explain why we do not see a significant difference in NTB between SAMI adopters and non-adopters.

Openness, as a personality trait, is defined by curiosity, imagination, and a willingness to try new things [11]. In our study, we observed high levels of openness across the entire class population. However, this trait is not inherently associated with a strong need for social acceptance or belonging, unlike traits such as agreeableness.

4 CONCLUSIONS

This study explored the potential of the AI agent SAMI, to enhance equity, a sense of belonging, and connectedness in online learning environments. The findings indicate that SAMI adoption is not influenced by learner demographics, suggesting its suitability for equitable use across diverse populations. Additionally, SAMI shows promise in fostering a stronger sense of belonging and connectedness among learners.

Contrary to expectations, the anticipated life cycle — where NTB serves as the motivation, a SOB as the outcome, and self-efficacy (SE) as an influencing factor — was not observed. Instead, the motivation to use social agents and seek belonging within course settings appears to arise from factors beyond NTB and SE, potentially driven by personality traits or goal-oriented objectives.

These encouraging results underscore the potential of AI-powered social agents to bridge social gaps and support more inclusive online learning experiences. However, further research is needed to examine the long-term effects of SAMI on learner engagement and educational outcomes. Investigating the specific mechanisms within SAMI that promote a SOB could inform the design and deployment of similar interventions in various online learning contexts. By advancing these tools and strategies, educators can cultivate more inclusive, engaging, and successful online learning environments for all learners.

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