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Fostering students' sense of belonging and enhancing higher order thinking: Exploring the role of pro-environmental behavior as a mediator and life autonomy as a moderator

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Abstract

The frequent emergence of global public crises has significantly disrupted educational paradigms, particularly with the widespread adoption of online learning methods. During this period, the sense of Students' Sense of Belonging (SSB) among students has been notably impacted. Although prior research has shown a significant correlation between SSB and higher-order thinking (HOT), there is still limited research on the precise nature of this relationship. This study undertakes a comprehensive investigation into the intricate connections linking SSB and HOT. A comprehensive survey was conducted to gather data from 776 students enrolled in a vocational college in China. The survey included evaluations of demographic information, psychological sense of school membership (SSB), higher-order thinking (HOT), pro-environmental behavior (PEB), and life autonomy (LA). Subsequently, multiple linear regression models were employed to analyze the complex relationships within this context. The study yielded several key findings: a positive correlation was observed between SSB and HOT. PEB acted as a moderator in the relationship between SSB and HOT, indicating a positive correlation between SSB, PEB, and HOT. LA also played a moderating role in the connection between PEB and HOT. Specifically, higher levels of LA attenuated the positive correlation between PEB and HOT. These results collectively suggest that SSB can serve as a stimulus for the development of HOT.

Keywords: College students, Higher-order thinking, Life autonomy, Mediated moderating model, Pro-environmental behavior, Students' Sense of Belonging.

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1. Introduction

In the aftermath of the COVID-19 pandemic, the world has witnessed an unprecedented sequence of public crises that have profoundly impacted numerous aspects of human life, including education, psychology, health, and living environments [1]. The imperative to curb the spread of contagious diseases has compelled universities worldwide to adopt emergency management strategies. These strategies include the widespread deployment of online learning [2], enforced isolation within closed communities and the stringent practice of social distancing. These measures, both within and beyond the confines of academic institutions, have confronted university students with a multitude of uncharted challenges, demanding the utilization of HOT skills to confront the evolving landscape.

HOT skills have become essential assets, allowing individuals to effectively navigate the complex web of information and arrive at logical conclusions amidst the noisy and contradictory narratives. This ability is particularly crucial in times of crisis, when widespread rumors and misinformation are prevalent [3]. Furthermore, HOT equips individuals with the capacity for creative problem-solving, particularly when confronted with unforeseen emergencies or radical shifts in circumstances. Importantly, it empowers individuals to make deliberate, well-considered decisions [4] in stark contrast to decisions driven by emotional impulses, which frequently result in impulsive and undesirable outcomes, especially within complex and volatile contexts, the imperative for a comprehensive exploration of the relationship between HOT and its associated variables becomes self-evident, offering critical insights into its impact and significance.

Amidst the shifts brought about by the public crises, the concept of SSB takes center stage. The protracted implementation of online learning and the transition to more autonomous study routines, driven by the need to adapt to the challenges posed by the pandemic, have led to a discernible reduction in SSB [5]. Students, confined to their virtual learning environments, grapple with the absence of the physical camaraderie that traditionally underpinned their educational experiences [6]. This lack of in-person interaction hinders the development of a sense of belonging, which includes acceptance, respect, tolerance, and support from peers and educators. This absence of a sense of belonging exerts a detrimental influence on students' overall well-being and academic pursuits. Conversely, students who are endowed with a strong SSB demonstrate an inclination to actively participate in online learning communities, fostering a fertile ground for the cultivation of HOT skills [7] alongside analytical aptitudes. Consequently, SSB emerges as a pivotal factor in nurturing students' HOT capabilities.

PEB represents another interlinked facet of this intricate web. As the duration of one's educational journey extends, so does their likelihood of engaging in environmentally responsible actions [8]. Social Identity Theory posits that an individual's behaviors and attitudes are influenced by their own sense of social identity and belonging. Individuals harboring a profound sense of students' sense of belonging are more inclined to exhibit PEB within their campus. Their heightened sense of affiliation further motivates active participation in various environmentally-focused initiatives [9]. Social Learning Theory emphasizes the significance of observational learning in the acquisition of behaviors. Therefore, students with a strong SSB to their school are more inclined to imitate and learn prosocial behaviors. Notably, environmental education endeavors in Indonesia have illuminated the role of SSB in facilitating environmentally conscious behaviors among college students. Intriguingly, PEB augments individual problem-solving acumen and creative thinking skills, thereby positively influencing their HOT capabilities [10]. However, the mediating role of PEB in the SSB and HOT relationship remains relatively underexplored.

Moreover, the link between PEB and HOT may be mediated by LA. In the context of public crises, students' learning and living environments have undergone drastic changes; the pursuit of effective learning becomes a formidable challenge [11]. Consequently, there is a heightened demand for students to cultivate robust LA competencies, encompassing life awareness, self-management, and self-directed learning attitudes. These competencies are instrumental, especially within the backdrop of a pandemic, in enhancing critical thinking and problem-solving proficiencies [12]. Furthermore, a relationship between students' self-directed learning attitudes and HOT has been established. Importantly, the relationship between SSB and HOT may be mediated by LA. Although a connection between LA, SSB, HOT, and PEB is discernible, research on the extent and nature of their interactions is very limited.

This study serves to address these gaps in our understanding. By focusing on the influence of SSB on HOT and the mediating role of PEB, alongside the moderating effects of LA, it seeks to offer tailored recommendations for the cultivation of college students' HOT capacities in the post-epidemic era. In doing so, it not only advances the frontiers of knowledge but also equips educators and policymakers with valuable insights into the intricacies of fostering HOT in a rapidly evolving educational landscape.

1.1. Students' Sense of Belonging and Higher Order Thinking

SSB is widely recognized as a crucial factor in students' development of HOT [13]. According to Goodenow [13] definition, Students' sense of belonging refers to the extent to which students feel accepted, respected, and supported by the school community. HOT is defined as mental activities that occur at a higher cognitive level, including problem solving, decision making, critical thinking, and creative thinking. According to self-determination theory, when an individual's needs for autonomy and belonging are satisfied in the environment, the individual's learning motivation is enhanced, making students more willing to challenge themselves and improve HOT. When students feel accepted and respected in their school community, they are more likely to actively participate in learning activities, which in turn promotes the development of HOT skills such as critical thinking, creative thinking, and problem solving [14].

At the same time, SSB brings a sense of mental security that motivates students to be more willing to challenge themselves in academic and social settings. This is an indispensable environmental condition for the development of HOT skills. Research has shown a positive correlation between an increased sense of belonging in school and the creative

thinking and critical thinking exhibited by students when dealing with complex problems [15]. The role of SSB is particularly critical in the post-pandemic context, as students' sense of psychological safety motivates them to actively participate in learning and social activities. Thus, it improves their HOT, such as critical thinking and problem-solving skills, with regard to public crisis events and information authenticity discrimination [14]. In addition, HOT benefits not only from enhanced engagement and safety but also from social interactions between students and the school. This perspective is precisely emphasized by constructivist learning theory [16].

According to the constructivist theory of learning, learning is a social process in which students construct knowledge within a specific socio-cultural context through interactions with peers and teachers. SSB, as a key factor in strengthening social interactions, can effectively promote the development of HOT skills. Specifically, when students feel a sense of belonging to a learning community, they are more likely to engage in discussion, cooperative learning, and critical reflection, which are key activities for the development of higher-order thinking. This feeling is based on students' favorable peer and teacher-student relationships. Research indicates that SSB makes students feel like they are part of the school community by promoting positive peer relationships. This provides students with opportunities for collaborative learning and exchange of ideas, which makes them willing to be challenged and explore new knowledge, thus enhancing HOT. On the other hand, SSB reinforces a trustworthy relationship between students and teachers, which is essential for promoting critical thinking and problem-solving skills. A good teacher-student relationship encourages students to ask questions, challenge assumptions, and share their opinions, all of which are key components of HOT.

As the vista of research continues to evolve, the internal mechanisms that intricately connect SSB and HOT remain somewhat fragmented and lack a systematic consensus. To illuminate and comprehensively comprehend the intricate relationship between these constructs, it is imperative to embark upon a deeper exploration of potential mediating and moderating factors that operate in the interstitial spaces between them.

In summary, the evidence suggests that college students' SSB, particularly in terms of nurturing creativity, honing problem-solving skills, and enhancing decision-making abilities, exerts a salutary influence on their HOT. Consequently, we formulate the following hypothesis:

H₁: Students' sense of belonging has a positive predictive effect on HOT.

1.2. The Mediating Role of Pro-Environmental Behavior

Numerous studies have established a correlation between PEB and SSB. Relative studies have verified that individuals with a high sense of belonging consider environmental behaviors as their own responsibility and are more likely to take proactive actions to protect the ecological environment and to implement PEB. Although few studies have explored the mechanism of PEB as an influencing variable for college students in the context of public emergencies, the above study shows that students with a stronger SSB exhibit HOT.

Furthermore, previous studies have proposed the concept of green creativity and verified the positive correlation between green creativity and PEB [17]. Moreover, some studies have demonstrated that individuals with stronger PEB are more inclined to do less harm to the environment and are willing to discuss and solve environmental problems through their own practical actions. This implies that the stronger the PEB is, the stronger the problem-solving ability is. Besides that, most researchers believe the main drivers of PEB for individuals or organizations include managerial cognition, technical competence, and competitive advantage, all of which would directly influence their decision-making in terms of environmental protection [18]. Based on the above studies, it is clear that the stronger an individual's PEB, the greater its impact on HOT skills (including creativity, problem-solving ability, and decision-making ability). Also, the stronger an individual's SSB is, the more it promotes PEB, which in turn enhances their HOT skills. As a result, the hypothesis is proposed:

H₂: PEB mediates the relationship between SSB and HOT

1.3. The Moderating Role of Life Autonomy LA

LA encapsulates a student's capacity to assume control over the trajectory of their lives, make independent choices, and shoulder responsibility for their actions [17]. The autonomy possessed by college students exerts a substantial influence on their overall life satisfaction, self-assessment, adaptability, as well as their psychological and physical well-being. Evidently, heightened levels of LA among college students correspond with elevated levels of mental health, self-appraisal, adaptability, and life satisfaction [19].

In terms of its impact on various facets of life, LA can be dichotomized into positive and negative dimensions. Negative LA is characterized by pessimism, indifference, low self-esteem, and a diminished moral compass. Confronting life with such a negative disposition can spawn an array of psychological challenges that significantly impede students' physical and mental development [20]. Conversely, positive LA serves as a counterbalance, mitigating or neutralizing negative emotions such as worry and anxiety. It not only enhances individuals' emotional well-being but also kindles their sense of purpose and life aspirations [21]. Of particular note, satisfaction and adaptability in life can further catalyze transformations in self-experience, interpersonal dynamics, and core life values. Consequently, individuals tend to form stronger emotional and psychological bonds with their living environment, resulting in an augmented SSB. It is evident that a significant correlation exists between positive LA and a robust SSB. Drawing upon these insights.

In addition, it is noteworthy that a positive and optimistic LA propels individuals to excel in problem-solving, creativity, HOT, and social development. Furthermore, by enhancing students' positive attitudes and autonomy towards nature, life, and learning, a positive LA can further stimulate students' intellectual potential and HOT skills. Consequently, a positive and optimistic LA bolsters individuals' resilience and sense of belonging in the school environment [22]. This, in

turn, empowers them to actively express their views and strategies for resolving collective problems or events, thereby promoting HOT. In other words, a positive LA exerts a constructive influence on the development of HOT skills.

LA significantly influences PEB. Prior research has affirmed that individuals with a positive LA tend to exhibit a heightened sense of personal responsibility and purpose [23]. There exists a notable direct effect of individual responsibility awareness on PEB. Additional studies have uncovered that an individual's LA, especially when oriented towards nature, prompts them to engage in significant PEB [24]. Positive LA and environmental awareness skills contribute to individuals' acquisition of environmental knowledge and significantly impact PEB [25]. College students' PEB, in turn, positively influences their HOT skills in terms of analysis, evaluation, and creativity [26]. Conversely, students harboring a negative attitude and a sense of life crisis often become reluctant to explore themselves, their families, and their environment, which leads to suboptimal learning outcomes. Furthermore, distinct value systems among different groups can yield varying levels of PEB, with egoistic LA displaying a negative correlation with PEB. Moreover, related research indicates that gender significantly influences LA, with males and females experiencing and expressing autonomy differently due to societal expectations, roles, and psychological challenges. Women's autonomy is often seen in the context of relational interdependence, valuing connectedness, whereas men tend to associate autonomy with independence and self-reliance [27]. These differences underline the complex relationship between gender and autonomy. Learner autonomy may be influenced by gender. In one study, there was no gender-based discrepancy in terms of learning experiences and challenges among EFL Indonesian students [28]. However, another study found that male students scored significantly higher than female students on self-acceptance but not on autonomy [29]. Additionally, this study revealed that the correlation between autonomy and self-acceptance was high for both genders. Furthermore, a study on university students found that there was a significant correlation between learner autonomy and education type, with students receiving conventional education perceiving themselves as more autonomous [30]. These findings suggest that while gender may play a role in certain aspects of autonomy, such as self-acceptance, it may not have a significant impact on overall learner autonomy. Given the unique circumstances of the COVID-19 pandemic and the fractured family structures it has engendered, students, despite their high LA, may exhibit indifference toward individuals and events in their surroundings. This ultimately diminishes their PEB. Thus, according to the discussion above, we propose:

H₃: The moderating role of LA, in PEB on the relationship between SSB and HOT.

2. Methodology

2.1. Research Design

A cross-sectional study was conducted to investigate the correlation between study variables. In this study, data were collected from 776 students at a vocational college in China in the wake of the COVID-19 pandemic. This added more information about the sample demographic data and ensured a broad representation across demographic characteristics. The data were collected at a specific time point through a structured questionnaire, and various constructs, including SSB, HOT, PEB, and LA, were measured and analyzed simultaneously to examine their relationships.

2.2. Measurement

Data collection was conducted through a structured questionnaire comprising several key constructs: the Psychological Sense of School Membership Scale (PSSM), HOT, PEB, LA, and demographic information.

Higher-Order Thinking Scale (HOT)

The Higher-Order Thinking Scale was developed by Hwang et al. [31] with 23 items [31]. It aims to examine students' level of HOT development in five areas: problem solving, critical thinking, teamwork, communication, and innovation. The scale's Cronbach's alpha in this study is 0.971, demonstrating that it may be used to gauge students' HOT. Participants rate themselves on a five-point Likert scale, with answers ranging from 1 (completely disagree) to 5 (strongly agree). Higher scores indicate higher levels of HOT, and conversely, lower scores indicate lower levels of HOT.

2.2.1. Psychological Sense of School Membership Scale (PSSM)

PSSM scale measures students' commitment to their school in terms of their feelings and behavioral attitudes. It was developed Goodenow [13] and has been widely used and translated into several languages. The Chinese version of the PSSM was developed by Pan et al. [32], Qin et al. [18] and has 18 items. The scale investigated participants' feelings, reactions, and approval levels, using a 5-point scale, with dimensions of perception, response, and recognition. The criteria "1" symbolizes never, "2" slightly not, "3" average, "4" slightly so, and "5" always so. The Psychological Sense of School Membership Scale in this study has a Cronbach's alpha coefficient of 0.838, indicating very high reliability. This study's PSSM, which measures its effectiveness in gauging SSB, has a coefficient of 0.838.

2.2.2. Pro-environmental Behavior Scale (PBS)

Lingqiang Zhou's self-rated PEB scale is used in this study. The consistency alpha coefficients of the original scale are all greater than 0.7, indicating that the original questionnaire has good stability [33]. The Pro-environmental Behavior Scale in this study has a Cronbach's alpha coefficient of 0.953, which indicates that the scale has a high degree of reliability. The scale consists of 11 items and 2 dimensions. There are 6 items related to public domain behavior and 5 items related to private domain behavior. Public domain behavior refers to environmental protection actions when individuals participate in public organizations, such as donating money to environmental organizations. Private domain behavior pertains to

individuals' environmental protection actions in their daily lives, such as purchasing environmentally friendly products. The instrument employs a 5-point scale to assess participants' feelings, responses, and agreement with the indicators. "1" indicates "strongly agree," "2" indicates "somewhat agree," "3" indicates "agree," "4" indicates "somewhat disagree," and "5" indicates "strongly disagree."

2.2.3. Life Autonomy Scale (LAS)

Hsieh [34] (a scholar at Tzu Chi University in Taiwan) developed the LA Scale (LAS) [34], and it contains 70 items, including six subscales: ideal, life autonomy, sense of being, love and care, life experience, and attitude toward death. In this study, the Cronbach's alpha of the scale is 0.825, indicating that the scale is reliable for measuring students. The reliability of the original scale is high, with a Cronbach's alpha of 0.93, demonstrating strong internal consistency. The subscale of life autonomy has six main dimensions: ideals, autonomy, love and care, sense of being, attitude toward death, and life experience (e.g., "I always play the role expected of me by others instead of doing what I really want to do," "I can choose the life I want to live," etc.). All items are scored on a 5-point Likert scale, from "totally disagree" to "totally agree," with questions 1-6 scored positively and questions 7-12 scored negatively. The greater the overall score, the more upbeat the outlook on life.

2.3. Procedure

This study focused on HOT among students in higher education institutions in Guangxi Zhuang Autonomous Region. The inclusion criteria encompassed students who willingly participated in the study for ethical reasons, with exclusion criteria barring students not affiliated with universities. The research employed random sampling, selecting 800 students from three schools. Questionnaires were distributed and gathered, with data subsequently organized and analyzed. The sample comprised sophomores and some juniors, totaling 776 valid responses in 44 undergraduate majors. Of these, 28.2% were male, and 71.8% were female, ranging in age from 19 to 25, reflecting a diverse and representative sample in terms of gender, age, and grade. Before initiating the questionnaire survey, the researcher conducted a preliminary exploratory focus group interview with students at the school to delve into their SSB and HOT capabilities. The majority of participants reported a diminished SSB during the post-pandemic period; they felt disconnected from the school community, which in turn impacted their engagement in HOT activities. They attributed this lack of connection to the disruption of regular school life caused by the pandemic, which not only affected their social interactions within the school environment but also their motivation to engage in complex thinking and learning tasks. This disconnection from the school community was seen as a significant barrier to fostering HOT, as students expressed a growing reluctance to participate in activities that require analytical thinking, problem-solving, and creative endeavors. Prior to data collection, ethical approval and informed consent were obtained.

2.4. Data Analysis

Collected data is subjected to comprehensive statistical analysis, including correlation analysis to explore relationships between variables, mediating analysis to investigate the potential mediating effect of PEB on SSB and HOT, and moderating mediation analysis to explore how LA moderates the relationship between PEB and HOT. Data is analyzed using advanced statistical techniques such as Pearson's correlation, regression analysis, and mediation and moderation analyses, conducted with PROCESS 4.1 developed by Hayes [35] in SPSS, to address the research hypotheses and provide a deeper understanding of the relationships among the variables.

Furthermore, before analyzing the data, responses are checked for completeness and outliers, and appropriate data cleaning procedures are employed to ensure data quality.

2.5. Ethical Considerations

The study adheres to ethical guidelines, including informed consent and data protection, and received approval from the relevant ethics committee. The studies involving human participants are reviewed and approved by the Institutional Review Board (IRB) of Liuzhou Vocational & Technical College, China. The ethical approval number is LVTC-2023-06-879. The current study confirms that informed consent is obtained from all participants involved in this research, ensuring their understanding of the research's purposes, procedures, potential benefits, and risks.

Table 1.
Correlation Among Variables.

Variables	Mean	SD	1	2	3	4
1. SSB	3.257	0.569	1			
2. HOT	3.709	0.681	0.582**	1		
3. PEB	3.478	0.748	0.555**	0.672**	1	
4. LA	3.543	0.601	0.546**	0.487**	0.413**	1

Note: ** correlation is significant at the 0.01 level (2-tailed).

3. Results

3.1. Descriptive Statistics

Table 1 presents the means, standard deviation, and inter-correlation for the study variables. The Pearson correlation coefficient in this study shows a value ranging from 0.413 to 0.582, thus indicating a positive and significant correlation

between all study variables. The results demonstrate that these correlation coefficient values are considered good indicators to proceed to the next stage of analysis.

3.2. Mediating Effect of PEB

Mediating analysis is conducted to explore the potential mediating role of PEB in the relationship between SSB and HOT. The results demonstrate that PEB significantly mediates the relationship between SSB and HOT, providing support for Hypothesis 2 (H2).

As shown in Table 2, there is a significant correlation between SSB and HOT ($\beta=0.363$, $SE=0.036$, $p<0.001$), which means SSB has a positive predictive effect on HOT, i.e., college students with higher levels of SSB have stronger HOT. This predictive effect remains significant when PEB is added ($\beta=0.331$, $SE=0.050$, 95% CI=[0.236, 0.434]), i.e., college students having higher PEB have stronger HOT. SSB has a significant positive effect on PEB ($\beta=0.730$, $SE=0.039$), $p<0.001$) and PEB has a significant positive effect on HOT ($\beta=0.454$, $SE=0.028$, $p<0.001$). PEB mediates HOT through a positive correlation with SSB. Additionally, the bias-corrected percentile bootstrap method further reveals a moderated mediating effect. The direct effect of SSB on HOT and the mediating effect of PEB between SSB and HOT do not contain zero values in the bootstrap confidence intervals (95%) (See Table 4). Therefore, SSB can directly influence HOT, or it can indirectly influence HOT through PEB, and the entire effect is split between the direct effect (52.30%) and the mediating effect (47.30%), respectively.

Table 2.

The Mediating Effect of PEB on the Relationship Between SSB and HOT.

Predictors	PEB					HOT				
	β	SE	t	95%CI		β	SE	t	95%CI	
				LLCI	ULCI				LLCI	ULCI
Age	-0.022	0.009	-2.468*	-0.04	-0.005	-0.001	0.007	-0.169	-0.015	0.013
Gender	0.067	0.05	1.35	-0.03	0.164	0.103	0.038	2.718**	0.029	0.177
Grade level	0.062	0.053	1.17	-0.042	0.166	0.298	0.041	0.735	-0.05	0.11
SSB	0.73	0.039	18.618**	0.653	0.807	0.363	0.036	10.052**	0.292	0.434
PEB						0.454	0.028	16.463**	0.399	0.508
PB x LA						-0.2	0.032	-6.337**	-0.262	-0.138
R-squ	0.318					0.52				
F	89.876**					166.586**				

Note: * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

*Analyses conducted using PROCESS model 14 with N = 776

Gender is dummy-coded (1, female, 2, male).

3.3. Moderated Mediating Effects

In order to validate H3, the second half of the mediated model is analyzed by adding LA as a moderating variable using the SPSS Process Model 14. Table 2 shows that the interaction between LA and PEB reaches a significant level ($\beta=-0.200$, $p<0.001$) with a 95% CI of [-0.262-0.138]. To better verify the mediating model with moderation, a simple slope test is used to analyze the moderating role of LA (see Figure 2). Table 4 shows that the moderating variables are grouped according to the mean score of LA plus or minus one standard deviation, with the mean plus one standard deviation being the high LA group and vice versa. Analysis of the results reveals the following findings:

(1) When the level of LA was low, college students showed a significant upward trend in HOT as the level of PEB increased (Effect=0.546, $t=16.970$, $p<0.001$).

(2) When the level of LA was high, college students showed a significant downward trend in HOT as the level of PEB increased (Effect=0.306, $t=9.184$, $p<0.001$).

Figure 1 shows a moderated mediating model in which LA regulates PEB by buffering the effects of PEB on HOT, and LA regulates the second stage of the mediating process, establishing a moderated mediating model for the second stage.

Table 3.

Total effect, direct effect and indirect effect among the variables.

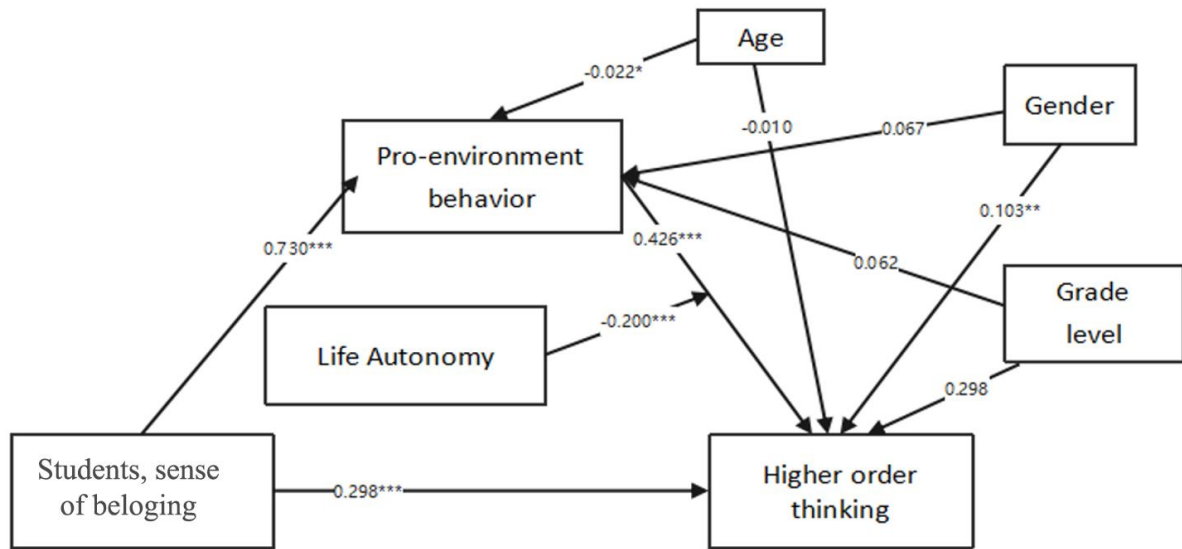
	Effect size	Boot SE	95%CI		Relative effect size
			LLCI	ULCI	
Total effect	0.694	0.035	0.625	0.762	
Direct effect	0.363	0.036	0.292	0.434	52.30%
Indirect effect	0.331	0.05	0.236	0.434	47.70%

Table 4.

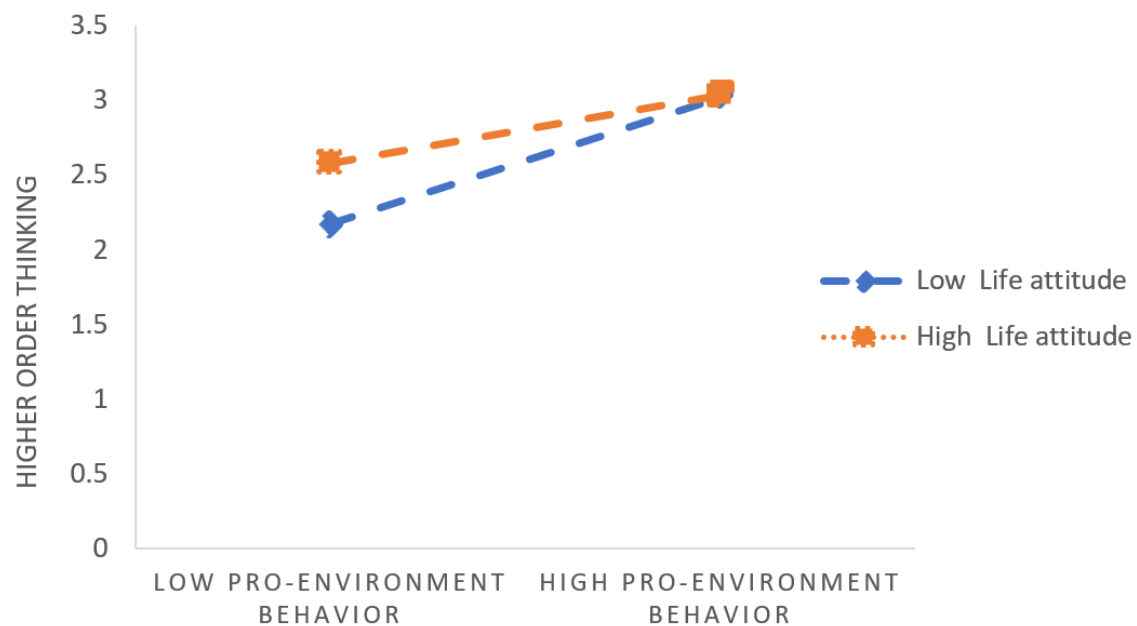
Results for the conditional indirect effect of SSB on HOT via PEB across LA.

Conditional effect of LA	Effect	Boot SE	95%CI	
			LLCI	ULCI
Low (M – 1 SD)	0.546	0.032	0.482	0.609
Medium (M)	0.426	0.027	0.373	0.478
High (M + 1 SD)	0.306	0.033	0.240	0.371

Bootstrap sample size = 5,000. Low: 1 SD below the mean. High: 1 SD above the mean.

**Figure 1.**

A model of the mediating role of Pro-environmental behavior and the moderating role of Life Autonomy

**Figure 2.**

Interactive effects of Pro-environmental behavior and Life Autonomy on Higher-order thinking.

4. Discussion

This study developed a moderated mediation model of SSB and HOT among college students. It was found that (1) SSB and HOT were positively correlated; (2) PEB mediated the relationship between SSB and HOT; specifically, SSB was positively correlated with PEB, and PEB was positively correlated with HOT; (3) LA mediated the relationship between PEB and HOT; specifically, higher LA reduced the positive correlation between PEB and HOT. These results are consistent with the hypotheses presented above.

First, the findings are consistent with H1 and related studies that SSB and HOT are positively correlated. SSB is lower when students are unable to feel accepted and included by others, leading to a reluctance to engage in collective thinking during learning and life. Consequently, they do not actively participate in classroom problem solving and find it difficult to

think critically, which does not stimulate students' HOT ability. Conversely, when SSB is higher, it can improve students' motivation to learn [36], encourage students to think critically about problems, and strengthen problem-solving and evaluation skills in learning. This leads to the enhancement of students' HOT. Research in brain science further supports this idea. From a brain science perspective, it has been found that being disconnected from the community and having a weaker sense of belonging can have a detrimental effect on the individual. When the brain detects the threat posed by communal disconnection and a low sense of belonging, the hypothalamic-pituitary-adrenal axis goes into overdrive, releasing the hormone cortisol, which negatively affects the prefrontal lobes. The prefrontal cortex is an area associated with higher-order cognitive abilities [37], and HOT is one of the important variables. It can be seen that being disconnected from the group and having a weak sense of belonging leads to a decrease in HOT abilities. When students have a strong sense of belonging and feel accepted, respected, and included by others, they develop stronger SSB. This can prompt individuals to stimulate stronger HOT competencies, such as creativity, problem solving, critical thinking, evaluative, and analytical skills [38]. These studies have demonstrated that SSB positively predicts HOT.

Second, the results of this study also validated the H2. It confirmed that SSB showed a positive correlation with PEB, and PEB showed a positive correlation with HOT, and that PEB acted as a mediator in SSB and HOT. Studies have shown that when students feel a high sense of belonging, they are more likely to make positive connections with people and the environment in their post-epidemic campus life and demonstrate stronger PEB. According to social identity theory, individuals define their social identities by belonging to certain groups, and this sense of identity influences their behaviors and attitudes. In the post-epidemic context, students' sense of belonging promotes identification with the school community. This identification makes students more inclined to adopt behaviors that are consistent with the values of the school community, including PEB. Meanwhile, SSB not only reinforces students' group identity but also facilitates their social interactions. Kirman and Teschl [39] found that such social interactions increase individuals' empathy, while empathy, in turn, positively promotes PEB in individuals. Thus, it can be seen that SSB is positively correlated with PEB.

Meanwhile, PEB is closely related to students' HOT. PEB promotes students' sense of community integration and improves their ability to utilize collective resources to solve problems. Also, PEB has a significant positive effect on HOT by stimulating students' critical thinking and creativity. For example, group exercises and environment-based learning experiences not only enhance students' problem-solving skills but also foster creativity [40] but also promote students' deeper understanding of post-epidemic environmental issues and the application of HOT skills. In addition, students' enjoyment of the learning environment prompted them to exhibit pro-environmental characteristics, which improved problem-solving skills. They participated in post-epidemic environmental activities, learned, and applied these skills in practice, which further strengthened the development of HOT skills.

Moreover, this study affirms that PEB acts as a mediator in the relationship between SSB and HOT in the post epidemic era. Casmana et al. [41] found that when students feel a strong SSB, they are more likely to exhibit PEB such as actively participating in environmental protection activities. Such participation, in turn, promotes students' HOT abilities including creativity, physical innovation, problem-solving skills, and critical thinking. This participation also promotes students' HOT abilities, including creativity, physical innovation, problem-solving skills, and critical thinking. Additionally, studies have shown that incorporating environmental protection elements into teaching is helpful in enhancing students' problem-solving skills and critical thinking. This is because students who are filled with a sense of responsibility are more likely to develop a sense of belonging, which promotes their PEB, and thus indirectly their problem-solving skills with respect to environmental issues [40]. In conclusion, these studies suggest that PEB has an important mediating function in the relationship between SSB and HOT abilities.

The findings consistently support Hypothesis 3 (H3) and highlight the intricate relationship between LA, SSB, PEB, and HOT. In addition, the study proposes that as LA deepens, it interacts with PEB and ultimately influences HOT, with LA acting as a mediator in the mediation model.

However, the present study differs from previous studies. It reveals that life autonomy diminishes the role of pro-environmental mediation of higher-order thinking in a post-epidemic environment. Previous studies showed that LA is positively correlated with an individual's PEB, and these behaviors further contributed to the development of HOT abilities. Imbarack Dagach et al. [42]. Findings from brain neuroscience suggest that positive life attitudes strengthen students' willingness to engage in group interactions by enhancing the production of dopamine neurotransmitters. This engagement promotes an individual's tendency to be close to nature and community and positively affects an individual's problem-solving ability and creativity [43]. This suggests that LA, by affecting dopamine production and release, may mediate the facilitating effect of PEB on HOT ability. In the post-epidemic context, LA (LA) has complex effects on the mediation between PEB (PEB) and HOT (HOT). Specifically, LA not only directly affects individuals' attitudes toward life and decision-making processes but also profoundly influences their environmental behaviors and cognitive development. This is reflected in the fact that the more individuals care about their life and autonomy, the less their PEB preferences are likely to be reduced, which in turn reduces HOT's ability to some extent. In this case and in the post-epidemic context, if students have more control over their self-life, they become less dependent on their environment. When they are more willing to believe that they can solve the problems in their life and study, the effect of PEB on HOT is weakened. On the contrary, when individuals' control over their own lives becomes weaker, their dependence on the environment becomes stronger. They are more inclined to utilize their surroundings to help improve their creativity and solve their problems, which enhances the positive effect of individual PEB on HOT.

This study involved only freshmen from one university and did not delve deeply into the specific majors of the participants, nor did it examine the impact of gender differences within these groups. Consequently, the findings did not account for potential variations in HOT among college students from different majors, grades, and gender identities. Future

research can aim to expand the sample to include students from diverse colleges and universities, incorporate a wider range of gender differences, and further investigate the influence of major differences on these variables. Overall, this study encourages further exploration into the relationship between SSB and HOT, recognizing that gender as well as contextual factors may play a nuanced role, while individual characteristics can significantly influence this dynamic relationship. Incorporating gender as a variable in future studies could provide deeper insights into how gender differences modulate the relationship among SSB, PEB, LA, and HOT. These considerations offer promising avenues for future research in this field.

5. Conclusion

In this study, we conducted an analysis of the relationship between SSB and HOT among college students in the post-pandemic context. We identified PEB as a mediating factor in this correlation, and LA plays a moderating role in the pathway connecting SSB, PEB, and HOT. The results showed: (1) SSB had a positive effect on HOT among college students. (2) PEB moderated the relationship between SSB and HOT. (3) LA moderated the mediating role of PEB, meaning that when LA was stronger, it would weaken the mediating role of PEB, but did not change the mediating role of PEB. In short, PEB and LA are important factors influencing students' HOT in the face of the challenges of public emergencies. Therefore, a new perspective on SSB, PEB, and LA should be explored to better understand the problems that college students may encounter in developing strong HOT in stressful and post-pandemic environments.

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