

A Mechanism Model of Social Participation Among Introverted Students in AI-Supported Gamified Classroom

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Abstract: In classroom environments with public expression, group discussions, and peer cooperation, introverted students encounter barriers in social participation due to participation styles, interaction pressure and limited situational support. This study adopts the inclusive education principle, uses literature analysis and theory synthesis to explore how artificial intelligence-supported gamification classrooms can promote social engagement. A three - dimensional mechanism model is proposed, which includes social safety, participation motivation and peer modeling. This model shows that AI - supported gamified classrooms can improve introverted students' social participation by reducing interaction risks, strengthening motivation, and enabling interactive experiences to be transferred to real peer environments. Based on the model, this study constructs a framework based on design principles, key components, and evaluation indicators, which is used to evaluate classroom design and effectiveness.

Keywords: Educational Technology; Artificial Intelligence; Gamified Classrooms; Introverted Students; Social Participation.

1. Introduction

Inclusive education belongs to the principle of educational fairness. It includes equal educational rights, equal access to public education resources, preferential allocation to socially disadvantaged groups and opposition to all educational privilege[1]. More broadly, reduce exclusion in the education system, so that all students can obtain fair education, meaningful learning opportunities, and achieve desired educational outcomes[2]. This perspective needs to adjust educational content, methods and structures to meet students' diverse needs[3]. In this framework, inclusive education technology has four core principles: adaptability, accessibility, acceptance, and participation, which help diverse learners participate in the education process[4] [2].

In contemporary classroom environments that focus on public expression, group discussions, and viewpoints, extroverted students are more likely to have anxiety, low self - confidence, social withdrawal and reduced participation, because their preferred participation styles are often in conflict with dominant interaction norms [5]. From the perspective of educational equity, classrooms need to provide "high social risk" students with personalized and accessible, comfortable and sustainable participation paths. The goal is not to turn introverted students into extraverts, but to explore how teaching and technology design can reduce barriers to participation and enhance the quality of participation, so that introverted students can participate in classroom interaction and cooperation in a way that is in line with their psychological comfort zone.

In terms of technology, recent advances have opened up new opportunities to alleviate classroom social participation barriers, especially imitative intelligent agents, which are artificial intelligence-based systems that simulate human behavior in specific situations through machine learning, and can also be used as virtual tutors and peers for students to interact in educational environments. In education, gamified teaching is increasingly used to promote positive learning, enhance learners' willingness to take challenges, and expand

students' capabilities through enriched learning[6] [7]. When artificial intelligence imitative agents are incorporated into gamification teaching, this combination can help introverted students participate in classroom social participation by providing safe simulated practice, personalized interactive support and behavioral modeling [8][9].

From an inclusive education perspective, student participation is not just about classroom performance, but also reflects students' ability to obtain support and experience inclusion in multiple aspects of school life. Social participation (social participation) is the key to the integration of schools and social interactions [10]. Social participation is an important part of social well-being, schools can promote it through positive social interaction and community building [11]. Relevant empirical research also points out that introversion is associated with social participation, providing empirical basis for understanding introverted students' social engagement in learning[12]. Existing research mainly focuses on introverted students' participation characteristics, gamified teaching motivational effects, or AI-supported learning applied value. However, there is a lack of integrative explanations of the mechanisms of classroom social participation promoted by introverts, as well as the framework connecting classroom design and effectiveness evaluation. Taking inclusive educational technology as a theoretical perspective, this study constructs a three-dimensional model of social security, participation motivation and peer modeling, explaining how artificial intelligence-supported gamification classrooms may promote introverted students' social participation in the classroom. This framework elaborates on design principles, key components and evaluation indicators, and helps to explain the design and effectiveness of classrooms.

2. Theoretical Foundations

2.1. Characteristics of Classroom Social Participation Among Introverted Students

Inadequate classroom social participation of introverted

students is not a lack of abilities or weak motivation; rather, it needs to be understood through personality traits and classroom environments. Research shows that introversion is often associated with more caution in social interaction, lower willingness to actively participate, and may also lead to social anxiety, affecting students' participation in classroom discussions and collaborative tasks. In discussions and collaboration, even if such students have completed sufficient preparation or formed clear views, they may reduce voluntary verbal participation, and may be less likely to take leading roles due to self-expression concerns. Some studies show that high-achievers, outgoing students and people with certain status in the class are relatively dominant: they are willing to express their views and opinions in communication and can also persuade peers to agree. In contrast, low-achieving and introverted students often remain silent or align with others' opinions [15]. Low-visibility participation is not necessarily a lack of cognitive engagement, but more often reflects the incomplete fit between students' preferred participation methods and classroom interaction demands [16][17][18][19], 17]. Peer support and social participation are used to moderate social anxiety and learn adaptation, highlighting the importance of positive peer interactions for introverted students.

2.2. The Motivational Foundations of Participation in Gamified Classrooms

Gamified teaching is an important way to promote classroom participation. Integrating game design principles, components and mechanisms into the teaching process can stimulate students' intrinsic motivation and active participation, enrich learning experience, promote cognitive development and ultimately improve learning results [22]. Tasks with clear goals and appropriate difficulty levels enable learners to feel proud when they complete challenges, and enjoyment, challenge and visible progress make them more willing to participate. However, more rewards may not necessarily bring better results. Excessive dependence on external rewards may weaken intrinsic interest; gamified design needs to treat rewards as a way to support intrinsic motivation, not a simple substitute [25]. Relying on immediate and constructive feedback can help learners see progress, correct errors and maintain interest, so as to enhance their sense of ability and engagement [26]. Overall, gamification has positive effects on learning outcomes, which can be achieved by improving engagement, satisfaction and intrinsic motivation[27].

2.3. The Interactive Support Foundations of AI-Based Imitative Intelligent Agents

AI - based imitative intelligent agents simulate human behavior in specific situations and interact with learners. They are virtual tutors, peer mentors or role - playing partners, and provide interactive scaffolding through emotions, personalized feedback, demonstration guidance, simulated practice and other methods [28]. Relevant research shows that teachers' emotional support, socio - emotional interaction in human - artificial intelligence collaboration and peer support all have an impact on students' engagement, school adjustment and sense of responsibility. Therefore, multi - agent systems and AI - assisted interaction may supplement classroom feedback or companionship, reduce the tension of interacting with real peers, and also create conditions for learning sharing, teamwork and transfer of interactional

experiences [29][30][31].

In addition, introversion and interactional caution are psychological restrictions on classroom social participation, gamification provides motivation for participation; artificial intelligence imitative intelligent agents provide low-risk interaction scaffolds. These three dimensions form the theoretical basis of the social safety - participation motivation - peer model model.

3. A Mechanism Model for Promoting the Social Participation of Introverted Students in AI-Supported Gamified Classrooms

3.1. The Overall Mechanism Chain: Social Safety-Participation Motivation-Peer Modeling

Introverted college students are prone to avoidant classroom interactions due to their personality, which will reduce their social participation. To solve this problem, this study proposes a three - part mechanism model that integrates social safety, motivation, and peer models. Specifically, this model shows that enhancing students' social safety in classroom interactions can stimulate their motivation for participation, promote more active participation with peers, and also support continuous classroom participation.

Social safety mechanism is to provide emotional support and low-risk interactive environments for students to overcome social anxiety and obstacles to participation, allowing them to express themselves freely. Participation motivation mechanism involves gamified classroom design, integrating students' intrinsic motivation and external feedback, making them more willing and confident to participate. Peer modeling is not only related to real peers but also to the ability of intelligent agents in the gamified classroom to simulate real peer interaction scenarios. Students have opportunities for interaction and can accumulate social experience.

3.2. The Social Safety Mechanism

Social safety mechanisms are to create a supportive low-risk classroom environment to reduce the social risks of classroom communication. When encountering public speaking and peer interactions, introverted students may have higher social anxiety and worry that their expressions/behavior may be negatively judged by others. It is also important to provide students with a low evaluative pressure environment, so that they can participate more actively in class. The construction of social safety mechanisms not only relies on classroom design, but also on teachers and peers' positive feedback. Teachers encourage and praise students' courage to interact, alleviate social anxiety and make classroom participation more confident[15][16]. The social safety mechanism also highlights the value of integrating anonymity into gamified behaviors. Studies have shown that anonymous environments reduce students' concerns about others' evaluations, and also motivate them to participate in classroom discussions or activities more actively [17]. When combined with artificial intelligence imitative intelligent agents (AI imi agents), gamified activities can enable students to have real-time interactions and feedback, while also providing personalized emotional support for them.

3.3. The Participation Motivation Mechanism

Participation motivation mechanism is to activate intrinsic motivation and strengthen it through external feedback to enhance students' motivation for classroom participation. In gamified classroom environments, well-designed games, challenging learning tasks and reward systems can increase the enjoyment and learning challenge of students [20][21]. Research has shown that learning motivation is activated not only by task difficulty or feedback, but also by aligning with students' interests and self-efficacy[22][23]. Therefore, gamified design needs to go beyond challenging tasks and feedback. It helps students recognize their progress in tasks, and also incorporates implicit task incentives that focus on self-efficacy strengthening. Integrating these implicit incentives into the gamified activity can gradually build students' confidence in interaction and enhance social participation.

In addition, a gamified classroom needs to structure tasks according to the hierarchical structure, so that students can cope with challenges gradually and at the appropriate pace. Artificial intelligence imitative intelligent agents need to provide personalized feedback and rewards to encourage students to participate in more interactive tasks. Introverted students gradually achieve small goals in gamified activities, and their motivation to participate is enhanced, enabling them to shift to more frequent classroom interactions and broader social participation.

3.4. The Peer Modeling Mechanism

Peer modeling helps students accumulate interaction experience in low-risk environments by simulating peer interactions. Introverted students often encounter tension and unease when interacting with peers, which makes it difficult to participate in active social interactions in the classroom. Integrating gamified elements with artificial intelligence

agents enables introverted students to interact with intelligent agents, enabling them to build social experiences through simulated classroom interactions. Artificial intelligence-based imitative agents can carry out personalized role-playing/interaction design based on students' interactive performance. Teachers rely on intelligent teaching design to play a key role: their insight into students, and intelligent agents' creative design can help create interactive virtual peers and real simulated tasks. These designs generate positive social feedback in the classroom and strengthen students' social participation ability [28][29].

Research shows that peer interaction has an impact on transferable skills. Students gradually accumulate interactional experiences through this process, and their confidence in interaction is strengthened, making it easy for them to transition to real peer interactions. In addition, imitative intelligent agents help students overcome anxiety, reduce social pressure, and also reduce self-imposed constraints when they are integrated into real classroom interactions.

4. Evaluation Framework

Inclusive education technology relies on technological means to promote equitable learner participation, and is guided by the four core principles: adaptation, accessibility, acceptance and participation [2]. This study constructs an evaluation framework to explore whether the integration of artificial intelligence imitative intelligent agents in gamified classrooms can enhance the social engagement of introverted students in the classroom. The framework includes design principles, key components and evaluation indicators (Figure 1). It transforms the three-part mechanisms model into an actionable path for instructional design, and also provides an operational basis for subsequent empirical research measurement.

Principles of Inclusive Educational Technology	Key Elements	Evaluation Indicators
Adaptability	Personalized difficulty levels and task pacing; differentiated feedback strategies; multi-role support (tutor, peer, and role-play)	Task-difficulty fit; frequency of negative responses; academic self-efficacy; duration of sustained participation
Accessibility	Low-threshold participation channels (anonymous, semi-anonymous, and text-to-speech scaffolding); progressive exposure pathways (AI practice → small-group interaction → whole-class participation); prompts and scaffolding	Rate of first-time verbal participation; response rate; duration of silence; perceived participation threshold; self-rated social anxiety
Acceptability	Non-judgmental and supportive language; culturally and contextually aligned interaction styles; safety boundaries and privacy prompts; non-humiliating evaluation mechanisms	Psychological safety; sense of being respected; fear of negative evaluation; sense of classroom belonging; comfort with AI-mediated interaction
Participation	Collaborative tasks and shared goals; peer-bridging activities (modeling-imitation-practice); teacher-agent collaborative support and shared decision-making	Contribution to collaboration; interaction quality (questioning/responding/summarizing structure); sense of peer connectedness; collaboration satisfaction; breadth of classroom participation

Figure 1. Evaluation Framework: Design Principles, Design Elements, and Evaluation Indicators

4.1. Adaptability: Regulating Tasks and Feedback to Address Differentiated Needs

Adaptability is to adjust instruction according to learners' individual needs. In this study, the authors say that in classrooms designed for introverted students, adaptive design

needs to calibrate the level of interaction challenges, task pacing and feedback, so that they are within a manageable range and do not exert excessive pressure. In this situation, adaptability is to help students adjust to classroom participation and expand the scope of engagement.

Design elements include the following: (1) The task difficulty, quantity and time pressure need to be adjusted

according to the learners' performance and emotional response, so that challenges can be achieved. For introverted students, differentiated feedback needs to be given, and the frequency and intensity should be carefully regulated to avoid excessive monitoring or stress. (3) Use multiple agent roles in the same classroom, so that students can choose the interaction partner they feel comfortable with and carry out tasks in a low - pressure environment.

Evaluation indicators include task completion, withdrawal rate, difficulty fit, frequency of frustration/ discouragement, score on the self-efficacy scale, duration of continuous participation, and return rate. These indicators are used to evaluate whether adaptive regulation can enhance students' stable engagement and competence.

4.2. Accessibility: Lowering Participation Thresholds Through Progressive Exposure Pathways

Accessibility is to ensure that learners have barriers to access educational resources. In classroom social participation, it is related to making participation easy to initiate. The key for introverted students is not to increase expressive demands, but to provide lower thresholds for expression and controllable exposure. Design elements include the following: Layered participation channels: Provide multiple expressions, such as text and emojis, multi-choice responses, oral contributions, so that learners start with low exposure forms and gradually move to high-exposure forms. (2) Introduce an anonymous or anonymous mechanism in the early stage of practice to reduce the fear of negative evaluations and establish an initial willingness to try again. (3) The interaction path is a stepwise progression, from artificial intelligence dialogue practice to brief responses in small groups, to the articulation of viewpoints in large groups and finally to whole class sharing, so as to reduce the avoidance caused by one - time high exposure demands. (4) Prompts or scaffolding: Provide prompt prompts, questioning frameworks and response options at key interaction points, reducing the cognitive burden of language organizing in real time, enabling learners to focus more on participation rather than anxiety management.

The evaluation indicators are the rate of first - time verbal participation, response rates, changes in silence duration, perceived participation thresholds, self - rated social anxiety and the proportion of transition from low - exposure channels to high - Exposure channels. These indicators need to evaluate whether the access to participation has been improved.

4.3. Acceptability: Supportive, Culturally Relevant, and Non-Judgmental Interaction Experiences

Acceptability is to embrace diversity through educational forms with high quality and culturally relevant content. In artificial intelligence imitative intelligent agents, gamified classrooms and so on, acceptability can be reflected in whether learners treat interactional language and evaluation practices as respectful and supportive, and do not tolerate humiliating, comparative or biased feedback. Design elements include the following: (1) Non - judgmental or supportive language norms: The agent's feedback should be encouraging, constructive and actionable, and avoid sarcasm, negative labels and public comparisons. (2) The consistency and cultural relevance of communication styles, role settings

and task narratives need to be consistent with the classroom culture and learners' backgrounds, so as not to feel uncomfortable or alienated due to contextually inappropriate "anthropomorphic performance". (3) In terms of safety boundaries and privacy prompts, clearly communicate the purpose or boundaries of interaction data, and provide mechanisms for stopping or not participating to reduce the feeling of being monitored.

Evaluation indicators include psychological safety scores, perceived respect score, fear of negative evaluations, sense of belonging in the classroom, comfort with artificial intelligence interaction, and fairness score. These indicators are used to evaluate whether classroom interaction is acceptable for learners.

4.4. Participation: From “AI-Supported Practice” to Participation in the Authentic Classroom Community

Participation promotes the full participation of learners or teachers in education decision-making. In this study, participation is not only related to the frequency of participation, but also to whether learners can establish stable interaction positions and collaborative roles in the classroom community, so as to transition from practice to real interaction. Design elements include the following: Classroom activities need to focus on collective tasks, reduce individual competition, and pay more attention to the division of labor and the success of shared goods. (2) Integrating activities (modeling - imitation - practice): Intelligent agents first model effective interaction, then guide learners to imitate these practices in task performance, and then transfer them to small group discussions and whole - class sharing. (3) Teacher - agent collaborative support: Teachers are responsible for classroom norms and relationship regulation, intelligent agents provide real - time prompts and low - pressure support. Learners need to participate in shaping classroom interaction rules through methods such as co-creating discussion norms, rotating roles, etc.

There are evaluation indicators, such as contribution to collaboration (such as peer assessment and task log), interaction quality, score on peer connection, collaboration satisfaction and classroom participation breadth. These indicators are used to evaluate whether learners shift from passive participation to real participation in the classroom.

5. Directions for Future Research

The effectiveness and underlying mechanisms of AI-based imitative intelligent agents in enhancing the social participation and learning motivation of introverted students within gamified instruction still require more robust empirical support. Future research should employ more rigorous research designs—particularly fine-grained studies focusing on small-sample groups—to examine their differential effects on the social participation of students with different personality profiles and to verify their practical effectiveness in educational settings. In particular, future studies may focus on the following questions: (1) Mechanism validation: Among the three pathways of social safety, participation motivation, and peer modeling, which mediating processes are most critical for enhancing social participation? (2) Design boundaries: Under what conditions do different combinations of gamification elements promote or inhibit the participation of introverted students? (3) Conditions of

transfer: How can AI-based practice be effectively transferred to authentic peer interaction, and is progressive bridging necessary for such changes to become stable over time? (4) Contextual variation: How do contextual factors—such as task type, collaboration requirements, teacher support, and classroom culture—affect the stability and generalizability of these effects?

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