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Mongolian students' learning style and experimental learning outcomes

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Abstract - Contemporary educational culture increasingly expects instructors to design instructional practices that accommodate diverse learning styles while conducting fair and unbiased assessments of students' learning progress. In response to these expectations, the present study aimed to identify the learning styles of Mongolian university students using standardized measurement instruments and to examine learning outcomes through the implementation of teaching methodologies aligned with these styles. Accordingly, this study compares different learning style preferences and examines their interrelationships. The learning styles of 986 undergraduate students **(**47% male) from the Mongolian National University of Education (MNUE) and the Mongolian University of Science and Technology (MUST) were assessed using the internationally recognized Felder–Solomon Index of Learning Styles (ILS)**.** The ILS instrument was selected due to its wide application in higher education research and its relevance to instructional design. Furthermore, the dimensions of learning and teaching styles proposed by R. M. Felder were employed to design an experimental instructional intervention. Based on the results of a pilot study conducted among students at MNUE, appropriate instructional methods were selected and organized in alignment with identified learning style distributions. In addition, a training strategy was developed by integrating principles derived from traditional Mongolian science, particularly the central view emphasizing physical, linguistic, and mental purity, alongside organizational principles drawn from management science. The experimental implementation involved 65 second-year undergraduate students majoring in Learning and Teaching at the School of Social Sciences. The instructional strategy was applied over the experimental period, and students' learning outcomes were evaluated using pre- and post-intervention assessments. Statistical analysis revealed a significant difference between pre-test and post-test learning outcomes ($p = 0.000$), with mean scores increasing from 78.78 to 91.68**,** respectively. Moreover, a strong positive correlation was observed between the overall pre- and post-test assessments ($R = 0.825$). These results indicate that the instructional intervention, designed in accordance with students' learning styles and culturally grounded pedagogical principles, contributed to a statistically significant improvement in learning outcomes, suggesting the effectiveness of the proposed training approach.

Key words: Deferent learning styles, Experiential learning approach, Learning outcomes

1. INTRODUCTION

In recent decades, higher education has increasingly emphasized learner-centered pedagogies that acknowledge individual differences in how students perceive, process, and apply knowledge. Among these differences, learning styles and experiential learning approaches have received growing attention as key determinants of academic engagement and learning outcomes. Understanding how students learn—and how instructional strategies align with their learning preferences—has become particularly important in the context of rapidly changing educational environments that demand adaptability, creativity, and reflective thinking [1].

Learning styles refer to relatively stable preferences in the ways learners acquire, organize, and interpret information. Various theoretical models have attempted to conceptualize these preferences, suggesting that students differ in their tendencies toward concrete experience versus abstract conceptualization, and reflective observation versus active experimentation. These differences influence not only how students approach learning tasks but also how effectively they benefit from particular instructional methods. Consequently, mismatches between teaching approaches and students' learning styles may limit the effectiveness of instruction, even when pedagogical content is well designed.

Experiential learning theory provides a powerful framework for addressing this challenge by emphasizing learning as a cyclical process grounded in experience, reflection, conceptualization, and experimentation. Rather than viewing learning as passive knowledge transmission, experiential learning conceptualizes it as an active, holistic process in which learners continuously construct meaning through interaction with their environment. Empirical studies have shown that experiential learning approaches—such as project-based learning, simulations, reflective practice, and field-based activities—can enhance higher-order thinking skills, learner autonomy, and practical competence.

Despite the growing international literature on learning styles and experiential learning outcomes, research focusing on Mongolian higher education students remains limited. Mongolia's educational context is characterized by a unique synthesis of traditional teacher-centered practices and emerging student-centered reforms. While recent policy initiatives have encouraged active learning and competency-based education, empirical evidence on how Mongolian students' learning styles interact with experiential learning strategies is still scarce. This gap limits the development of contextually responsive pedagogical models that reflect both learners' cognitive preferences and cultural learning orientations.

Moreover, examining learning styles and experiential learning outcomes within the Mongolian context offers broader theoretical significance. From a contemporary educational perspective, learning can be understood as a dynamic, non-linear, and context-sensitive process—an understanding that resonates with systems-based and quantum-oriented views of learning. In this sense, learners are not passive recipients of instruction but active participants whose internal states, experiences, and environments interact to shape learning outcomes. Investigating these interactions empirically contributes to a deeper understanding of learning as an emergent phenomenon rather than a linear cause–effect process.

Therefore, the present study aims to examine the relationship between Mongolian university students' learning styles and their experiential learning outcomes. Specifically, it seeks to identify dominant learning style patterns among Mongolian students and to analyze how these patterns influence learning outcomes within experiential learning environments. By doing so, the study intends to contribute both practical implications for instructional design in higher education and theoretical insights into learner-centered and experience-based learning frameworks.

The findings of this study are expected to inform educators, curriculum designers, and policymakers by providing evidence-based guidance on how experiential learning approaches can be better aligned with students' learning styles. Ultimately, such alignment may enhance learning effectiveness, foster deeper engagement, and support the development of adaptive, reflective, and self-directed learners in Mongolian higher education.

1.1 Research questions

RQ1: What is the relationship between Mongolian students' learning styles and their experimental learning outcomes?
RQ2: Are there significant differences in experimental learning outcomes across different learning styles?
RQ3: How does the interaction between learner, learning environment, and experience shape experimental learning outcomes among Mongolian students?
RQ4: How does identifying students' learning styles and implementing learning activities tailored to them contribute to the application of the Quantum Approach to teaching and learning?

The overall goal of the study is to determine the learning styles of Mongolian university students and to experimentally study how the implementation of experiential learning methods that are consistent with these styles affects learning outcomes.

Specific research objectives:

1) Identify the learning styles of Mongolian students
2) Using standardized learning style scales (Felder–Silverman) to identify the dominant styles of students.
3) Implement experiential learning methodologies in accordance with learning styles
4) Determine the impact of learning methodologies that are consistent with learning styles on learning outcomes
5) Perform statistical analyses using correlation, and regression.
6) Explain the multivariate and coherent nature of learning from a quantum perspective.

1.2 Research Design

This study employed a mixed-methods research design, integrating both quantitative and qualitative approaches to examine the relationship between Mongolian students' learning styles and their experiential learning outcomes. A sequential explanatory design was adopted, in which quantitative data were collected and analyzed first, followed by qualitative data to further explain and interpret the quantitative results.

Participants and Sampling:

- The participants were undergraduate students from major Mongolian universities.
- Sample size: approximately 800–1,000 students
- Gender, academic major, and year of study were considered
- Stratified random sampling was used to ensure representative participation across disciplines

2. THEORETICAL BACKGROUND

2.1 Learning and Learning Styles

The growing integration of face-to-face and e-learning modalities has highlighted the need to better understand individual differences in learners' characteristics and learning styles. Despite advances in educational technology, learning environments often fail to adequately account for students' innate preferences, cognitive processing differences, and brain-based learning principles. Consequently, there is a need for instructional designs and management strategies that align learning methodologies with diverse learning styles.

Experiential learning theory provides a foundational framework for understanding learning styles. Kolb [2] conceptualized learning as a process through which knowledge is created via the transformation of experience, emphasizing the dynamic interplay between experience acquisition and experience transformation. He identified two core dimensions of learning: active experimentation and reflective observation, which together explain how learners process and internalize information. Kolb's Learning Style Inventory is theoretically grounded in Dewey's experiential philosophy, Lewin's emphasis on active participation, and Piaget's interactionist view of cognitive development [2].

Extensive research demonstrates that learners differ systematically in how they perceive, process, and respond to information. Felder [3] argued that students preferentially attend to different types of information, process it in distinct ways, and achieve understanding at varying rates. Learning styles thus represent characteristic patterns through which individuals acquire, retain, and retrieve knowledge [4]. James and Gardner [5] further defined learning styles as the most efficient and effective ways learners perceive, process, store, and recall information.

Theoretical perspectives on learning styles also recognize both commonality and individuality among learners. As noted by Kluckhohn and Murray [6], individuals are simultaneously similar to all people, similar to some, and unique from others. Curry and Adams [7] emphasized that learning styles reflect habitual tendencies in acquiring knowledge, skills, and attitudes, reinforcing the need for instructional approaches that are flexible rather than uniform.

To address learning style diversity, scholars highlight the role of multimedia and innovative instructional strategies. The use of varied media formats and learner-centered technologies has been shown to support different cognitive preferences and enhance learning effectiveness [8]. In response, numerous conceptual models and inventories of learning styles have been developed over the past decades, reflecting sustained scholarly efforts to operationalize individual differences in learning (see Table 1).

Table 1. A Summary of Learning Style Models or Inventories

Model / Inventory	**Dimensions**
Kolb (1984)	converger, diverger, assimilator, accommodator
Reid (1984)	visual, auditory, kinesthetic, tactile, group, individual
Felder and Silverman (1988)	sensing/intuitive, visual/verbal, inductive/deductive, active/reflective, sequential/global
O'Brien (1990)	visual, auditory, haptic
Fleming and Mills (1992)	visual, aural/auditory, read/write, kinesthetic
Oxford (1993)	visual/auditory/hands-on, extroverted/introverted, intuitive/concrete-sequential, closure-oriented/open, global/analytical
Kinsella (1993)	visual/verbal, visual/nonverbal, auditory, tactilekinesthetic
Ely (1994)	tolerance of ambiguity, intolerance of ambiguity
Memletics Learning Styles Inventory (2003)	visual, auditory, verbal, physical, logical, social, solitary

Source: SiSAL Journal Vol. 5, No. 2, June 2014, 112-126 (Jing, 2014)

2.2 Students' Individual Qualities and Learning Styles

Students differ substantially in their cognitive characteristics, prior knowledge, and preferred ways of processing information, all of which influence learning outcomes. One influential framework for understanding these differences is the VARK model, which identifies four learning modalities: visual, auditory, reading/writing, and kinesthetic [9]. These modalities reflect common experiential patterns and highlight the importance of multimodal instructional design.

The emphasis on experience-based learning has deep roots in educational theory. Early reformers such as Pestalozzi advocated learning through action and concrete experience rather than rote memorization, an idea later reinforced by Dewey's "learning by doing" philosophy in progressive education [10]. By the late twentieth century, experiential and laboratory-based instruction had become central to science education, underscoring the pedagogical value of active engagement.

Beyond instructional modality, research on discourse comprehension demonstrates that learning is shaped by how information is linguistically and structurally organized. Discourse context, connectives, syntactic cues, and textual organization guide attention, support coherence, and influence memory formation [11-13]. Structural signals such as headings further enhance comprehension and recall by clarifying conceptual relationships [14].

Individual differences, particularly prior knowledge, are among the strongest predictors of comprehension and learning. Prior knowledge supports inference generation, prediction, and integration of new information, with its effectiveness depending on the coherence and adaptability of the learner's knowledge base [15, 16].

The Felder–Soloman Index of Learning Styles further conceptualizes learning differences across four dimensions—active–reflective, sensing–intuitive, visual–verbal, and sequential–global—describing habitual patterns of information processing and problem-solving [17]. Collectively, these perspectives underscore the need for flexible, learner-centered instructional designs that accommodate cognitive diversity. Based on extensive teaching experience, learning styles represent learners' dominant patterns of interaction within a dynamic learning system, thereby providing a concrete and theoretically grounded entry point for quantum-oriented pedagogy.

3. DATA AND METHODS

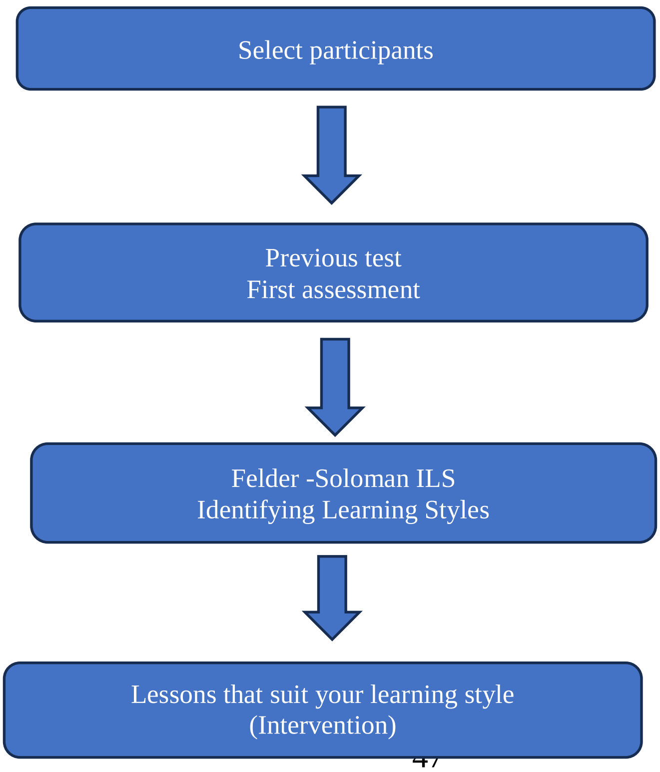
3.1 Instruments Methods

The **Felder–Silverman Index of Learning Styles (ILS)** was administered to identify students' preferred learning styles [18, 19]. The instrument comprises four bipolar dimensions—active–reflective, sensing–intuitive, visual–verbal, and sequential–global—with 11 items per dimension (44 items in total). Each item requires a dichotomous response (a or b). Dimension scores range from –11 to +11, reflecting both the orientation and the degree of preference for each learning style.

The Felder Index of Learning Styles (ILS) was used to identify students' learning style profiles. Data were analyzed using SPSS**,** with comparisons conducted across school, gender, and field of study. Descriptive statistics and internal consistency measures were computed, followed by analysis of variance (ANOVA) to examine group differences.

Guided by Felder's learning and teaching style dimensions and established instructional frameworks, the study implemented learning-style-aligned teaching strategies and instructional materials**.** Participants were sampled, instructional interventions were conducted, and outcomes were analyzed to evaluate the effectiveness of the approach (see Fig. 1). Survey data were analyzed using SPSS, with comparisons conducted across school, gender, and field of study. Descriptive statistics, mean scores, and internal consistency estimates were computed, followed by analysis of variance (ANOVA) to identify significant group differences. Guided by Felder's theoretical framework and prior methodological research, learning-style-aligned instructional strategies and materials were implemented through experimental teaching sessions. Learning outcomes were measured and analyzed to evaluate the effectiveness of the intervention (see Fig. 1).

Quasi-experimental design



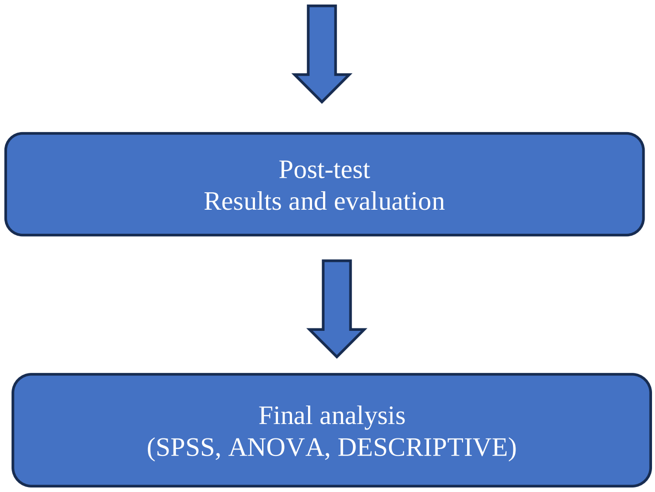


Fig 1. Quasi-Experimental design: One-Group Pretest/Posttest Design in Practice

(**Source.** Campbell & Stanley (1963) — *Experimental and Quasi-Experimental Designs for Research* (seminal work in research methodology)

3.2 Participants

A total of 986 students participated in the study, including 462 men (46.9%) and 524 women (53.1%). Of these, 499 students (50.6%) were enrolled in education programs at the Mongolian National University of Education (MNUE), while 487 students (49.4%) were enrolled in engineering programs at the Mongolian University of Science and Technology (MUST). This study involving human participants received ethical approval in compliance with established human rights and research ethics standards.

Gender distribution differed markedly by field of study: 18% of education students were male, whereas 76% of engineering students were male (see Table 2). This distribution reflects a broader pattern of gender-based specialization, with women predominantly represented in teacher education and men in engineering disciplines.

Regarding age, the majority of participants were 18 years old (n = 533, 54.1%), followed by those aged 19 years (n = 243, 24.6%), 20 years (n = 121, 12.3%), and 21 years (n = 59, 6.0%). A smaller proportion of participants were 26 years old (n = 26, 2.6%), while only four students (0.4%) were aged 22 or 23 years.

Table 2. General information of the surveyed students

	Number of students	Percentage of male students
MNUE /Education/	499	18%
MUST /Engineering/	487	76%
Total	986	47%

The analysis of survey data is presented as aggregated distributions of Felder ILS preferences (see Fig. 2). Learning style preferences were categorized as strong (scores 4–11 in either direction) and balanced (scores between –3 and +3). Figure 2 displays the number and percentage of students across the full scale range (11b to 11a).

Results indicate that 66.7% of students exhibited a balanced active–reflective profile, while 21.6% showed a strong preference for the active style and 11.7% for the reflective style. Reflective learners tend to prefer quiet, individual thinking before action, whereas active learners favor discussion, application, and collaborative learning and often find it difficult to attend lectures without note-taking [17, 20].

For the sensing–intuitive dimension, 71.5% of students demonstrated a balanced profile, 24.0% showed a strong sensing preference, and 4.5% a strong intuitive preference. Sensing learners favor factual information, established procedures, and practical tasks, while intuitive learners are more comfortable with abstraction, theory, and discovering relationships independently [3, 20].

In the visual–verbal dimension, the majority of students (73.5%) exhibited a balanced preference, with 15.1% showing strong verbal dominance and 11.4% strong visual dominance. Balanced visual–verbal processing is characteristic of effective learners who can integrate information across modalities (Felder & Soloman, 2000).

Finally, 76.7% of students demonstrated a balanced sequential–global profile, while 17.1% were strongly sequential and **6.2%** strongly global. Sequential learners prefer step-by-step information processing, whereas global learners tend to grasp complex material holistically [21].

Figure 2. General results of students' learning style

213(21.6%)										115(11.7%)	
ACT					658(66.7%)						**REF**
11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b
237(24%)										44(4.5%)	
SEN					705(71.5%)						**INT**
11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b
112(11.4%)										149(15.1%)	
VIS					725(73.5%)						**VRB**
11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b
169(17.1%)										61(6.2%)	
SEQ					756(76.7%)						**GLO**
11a	9a	7a	5a	3a	1a	1b	3b	5b	7b	9b	11b

Note. Felder ILS score interpretation follows standard conventions: scores ranging from 5a to 11a indicate a preference toward Active (ACT), Sensing (SEN), Visual (VIS), and Sequential (SEQ) learning styles; scores between 3a and 3b represent a moderate (balanced) preference; and scores from 5b to 11b indicate a preference toward Reflective (REF), Intuitive (INT), Verbal (VRB), and Global (GLO) learning styles.

4. RESULTS

4.1 T-TEST AND ANOVA

Students were grouped by school (field of study) and compared across the four Felder ILS dimensions. Independent-samples tests revealed statistically significant differences between education and engineering students on all dimensions (see Table 3): active–reflective (F = 10.65, p = .001), sensing–intuitive (F = 7.97, p = .005), visual–verbal (F = 15.68, p < .001), and sequential–global (F = 8.62, p = .003).

Mean scores highlighted distinct learning style tendencies. Education students at the Mongolian National University of Education (MNUE) scored higher on sensing–intuitive (M = 1.95), active–reflective (M = 1.19), sequential–global (M = 0.71), and visual–verbal (M = 0.04). In contrast, engineering students at the Mongolian University of Science and Technology (MUST) demonstrated lower scores for active–reflective (M = 0.37) and sensing–intuitive (M = 1.37), a stronger preference for the visual end of the visual–verbal dimension (M = –0.86), and higher sequential–global scores

(M = 1.31). These results indicate that learning style preferences differ substantially by academic discipline, emphasizing the need for instructional strategies tailored to students' professional learning profiles.

Table 3. Independent-samples T-Test results for comparisons of ILS scores between schools/professional fields

School	N	ACT(+) REF (-)		SEN(+) INT (-)		VIS(+) VER (-)		SEQ(+) GLO (-)	
		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Education /MNUE/	499	1.19	3.86	1.95	3.48	0.04	3.95	0.71	3.29
Engineering /MUST/	487	0.37	3.98	1.37	3.04	-0.86	3.10	1.31	3.17
Total	986	0.78	3.94	1.66	3.28	-0.40	3.58	1.01	3.24
sig	F	10.65		7.97		15.68		8.62	
	p	0.001		0.005		0.00		0.003	

$P^* < 0.05$

Analysis of learning styles by gender revealed significant differences in the sensing–intuitive (p = .003) and visual–verbal (p < .001) dimensions (see Table 4). Male students scored slightly higher on the intuitive (M = –0.03) and verbal (M = –0.05) dimensions, while female students scored slightly higher on the sensing (M = 0.03) and visual (M = 0.05) dimensions. These findings suggest subtle gender-related variations in learning style preferences, which may inform the design of gender-sensitive instructional strategies.

Table 4**.** Independent-samples T-Test results for ILS scores by gender

	N	ACT(+) REF (-)		SEN(+) INT (-)		VIS(+) VER (-)		SEQ(+) GLO (-)	
		Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Male	462	-0.03	1.01	-0.03	0.93	-0.05	0.92	0.09	0.99
Female	524	0.03	0.99	0.03	1.06	0.05	1.06	-0.08	1.01
Total	986	0.78	3.94	1.66	3.28	-0.4	3.58	1.01	3.24
Sig		p= 0.297		p=0.003		p=0.000		p=0.520	

Of the students surveyed, 572 (58%) were first-year, 182 (18.5%) second-year, 166 (19.8%) third-year, and 66 (6.7%) fourth-year students (see Table 5). A statistically significant difference by year of study was observed for the visual–verbal dimension (F = 7.77, p < .001), whereas no significant differences were found for the other learning style dimensions. Fourth-year students demonstrated a greater preference for the visual style (M = 0.36), while first-year students favored the verbal style (M = –0.12). These findings suggest that as students advance through their programs, they increasingly adopt a visual learning style [22].

Table 5**.** ANOVA results for comparisons of ILS scores by year of study

N		ACT(+) REF (-)		SEN(+) INT (-)		VIS(+) VER (-)		SEQ(+) GLO (-)	
		Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation	Mean	Std Deviation
1-р курс	572	-0.05	0.99	-0.02	0.98	-0.12	0.92	0.05	0.97
2-р курс	182	0.08	0.96	0.00	1.07	0.12	1.06	-0.05	1.08
3-р курс	166	0.11	1.06	0.06	1.07	0.14	1.14	-0.09	0.96
4-р курс	66	-0.08	1.08	0.04	0.83	0.36	0.93	-0.02	1.14
Total	986	0.00	1.00	0.00	1.00	0.00	1.00	0.00	1.00
ANOVA		F=1.620		F=0.347		F=7.766		F=1.048	
		p=0.183		p=0.791		p=0.00		p=0.370	

$P^{*} < 0.05$

From the larger sample, 65 students from the School of Social Sciences and Humanities at the Mongolian State University of Education were randomly selected to participate in a group practice lesson for the *Fundamentals of Learning and Teaching* course.

Prior to the intervention, the Felder–Soloman ILS was administered to assess participants' learning style preferences (see Table 6). Based on the results, the practice lesson was prepared with teaching aids and instructional strategies tailored to the students' dominant learning styles. Among the participants, 44.6% exhibited a strong visual learning preference, and 47.7% demonstrated a strong active style. Scores for sensing–intuitive and sequential–global dimensions were predominantly moderate, indicating a more balanced profile in these areas.

This preparatory step ensured that instructional methods were aligned with individual learning preferences, allowing subsequent evaluation of the effectiveness of style-adapted teaching strategies.

Table 6**.** Learning style indicators for practice lesson participants (n = 65)

Active-Reflective		Frequency	Percent
Valid	Active /strong/	31	47.7
	Moderate	33	50.8
	Reflective /strong/	1	1.5
	Total	65	100.0
	Perception		
Sensing-Intuitive		Frequency	Percent
Valid	Sensing /strong/	5	7.7
	Moderate	56	86.2
	Intuitive /strong/	4	6.2
	Total	65	100.0
	Input		
Visual-Verbal		Frequency	Percent
Valid	Visual /strong/	29	44.6
	Moderate	33	50.8
	Verbal /strong/	3	4.6
	Total	65	100.0
	Comprehension		
Sequential-Global		Frequency	Percent
Valid	Sequential /strong/	1	1.5
	Moderate	57	87.7
	Global /strong/	7	10.8
	Total	65	100.0

4.2 Experimental Procedure

During the first trimester of the 2024–2025 academic year, a one-group quasi-experimental study was conducted. The intervention consisted of 16 hours of instruction on the *Fundamentals of Learning and Teaching* course, evenly divided into 8 hours of lectures and 8 hours of seminars.

Prior to the experimental sessions, instructional strategies, teaching materials, and learning tools were designed in alignment with students' learning styles. The design drew on Felder's Dimensions of Learning and Teaching Styles [18] and approaches suggested by Graf et al.[23], Gulbahar and Alper [24], Kolekar et al. [25], and Pitigala Liyanage et al. [26]. Table 7 summarizes the learning style–aligned teaching methods and materials applied in the experiment.

This preparatory step ensured that the lecture and seminar activities were tailored to the participants' dominant learning preferences, allowing for a controlled evaluation of style-adapted instructional effectiveness.

Table 7. Preferred learning styles and corresponding teaching strategies

		LEARNING STYLES							
		Sensing	Intuitive	Visual	Verbal	Active	Reflective	Sequential	Global
LEARNING OBJECTS	Presentations		✓	✓		✓	✓		
	Video	✓	✓	✓	✓	✓	✓		
	PDF content		✓			✓	✓		
	Email				✓				
	Worksheets, Printed Materials	✓				✓		✓	
	Topic list, Intellectual mapping		✓	✓					✓
	Audio	✓			✓				
	Figures, graphs, diagrams, charts and tables			✓				✓	
	Bibliography		✓				✓		✓
	Website		✓		✓			✓	✓
	Self-assessment					✓	✓		
	Book guide						✓	✓	
Corresponding TEACHING STYLE	Teamwork				+	+			
	Learn by doing	+				+		+	
	Teaching practice, role-playing, acting	+				+			
	Cornell taking notes			+		+			+
	Discussion				+	+			
	Project-based training		+						+
	Case study, real life, fact-based exercise case study	+				+	+		
	Problem solving training		+						
	Observational learning			+			+		
	Self-assessment		+				+		
	Task-based training	+						+	
	Step by step word processing exercises	+						+	
	Online Research		+				+		+
	Laboratory work	+				+		+	
	Loud reading method	+			+			+	
	Lecture method				+				
	Making assumptions		+				+		+

The experimental results suggest that the Quantum Approach views learning as a dynamic, interactive, and nonlinear process, where learning outcomes emerge through the interaction of the learner, the learning environment, and instructional design. Within this framework, learning styles function as empirically observable indicators of learners' preferred modes of interaction. Recognizing these styles allows core quantum principles, including interaction, coherence, and emergence, to be operationalized in instructional practice.

4.3 Instructional Materials and Teaching Methods

During the experimental training, active and visual style–aligned materials were employed, including PowerPoint presentations, videos, PDFs, printable worksheets, pictures, graphics, diagrams, charts, and tables. Instructional methods incorporated demonstrations, teamwork, role-playing, learning-by-teaching, case studies, documentation, discussions, and corner note-taking, ensuring alignment with students' dominant learning preferences.

To support and strengthen weaker learning styles, supplementary techniques such as flipped learning, student presentations, self-assessment, evaluation, and hypothesis generation were implemented. Exercises and tasks were explained in detail, and participants received counseling, guidance, and motivational incentives to minimize learning difficulties.

For example, students were provided in advance with a case describing a teacher's philosophy and attitude and asked to identify the instructor's ideological stance. While performing the same task, students were encouraged to personalize their responses using digital tools, photographs, or visual representations, in addition to oral explanations. During lectures, Cornell note-taking and mind-mapping tools were used to promote critical and analytical thinking, topic integration, and effective feedback.

These strategies ensured that instruction was tailored to students' learning profiles, while also fostering engagement, creativity, and higher-order cognitive skills.

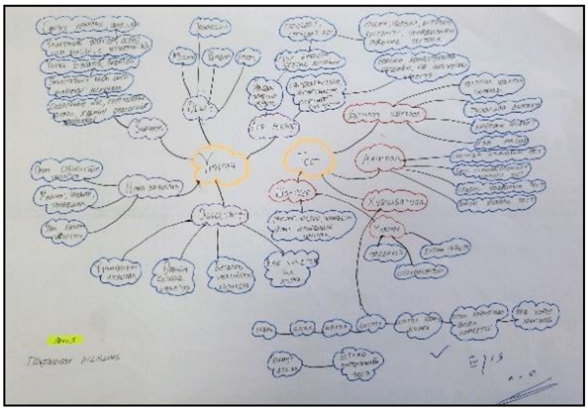


Figure 3. Example of mind mapping used during the pilot lesson

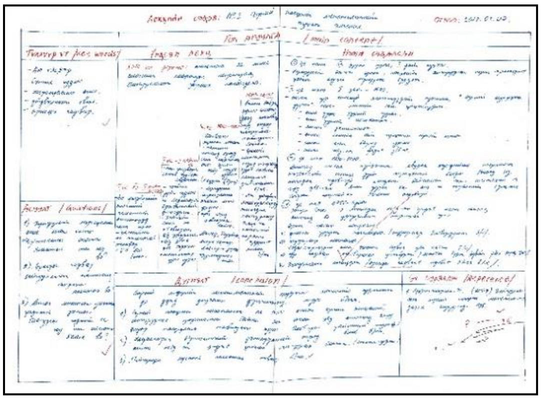


Figure 4. Example of Cornell note-taking used during the pilot lesson

4.4 Effects of Mind Mapping on Student Learning

The use of mind mapping during the pilot sessions yielded several notable outcomes:

- Students found mind mapping to be highly engaging, enjoyable, and stimulating, increasing motivation and active participation.
- Many students creatively and enthusiastically contributed to mind map construction, incorporating colors, symbols, images, keywords, and designs.
- Students reported that mind mapping facilitated the achievement of cognitive learning objectives, enhancing comprehension and knowledge retention.
- While collaborative work was available, students generally preferred individual mind mapping, as it provided the opportunity to express their ideas freely.
- Pupils recognized that mind maps offer multiple strategies for studying, leading to improvements in focus, reflection, opinion expression, and note-taking skills.
- The integration of images and visual cues was particularly appealing, as students felt it did not resemble traditional note-taking.
- Students highlighted the utility of mind maps for quick recall during tests and exams, as visual links helped them remember key concepts and connections efficiently.

Overall, mind mapping was perceived as a powerful tool for active, personalized learning, supporting both cognitive development and independent thinking.

Consequently, mind mapping provides an effective learning strategy for students with a predominantly verbal learning style, and its use can be integrated into the curriculum and course materials to enhance comprehension and retention. Similarly, Cornell note-taking proves to be a valuable method for structuring information, facilitating active engagement, reflection, and efficient review, and supporting the development of critical thinking and independent learning skills.

Table 8**.** Cornell Note-Taking Method: Key Features and Benefits

Component	Description	Learning Benefits
Cue Column	Key terms, questions, or prompts recorded on the left side of the page	Facilitates active recall, questioning, and connection of ideas
Note-Taking Column	Main lecture notes, concepts, examples, and explanations on the right side	Supports organization of information and comprehension during learning
Summary Section	Concise summary of the lecture at the bottom of the page	Reinforces understanding, reflection, and memory retention
Review & Reflection	Regular review of notes, self-questioning, and elaboration	Enhances critical thinking, knowledge integration, and exam preparation

Note. Adapted from Pauk (1950), "How to Study in College.**"** The Cornell method promotes structured, active, and reflective note-taking, supporting both visual and verbal learning preferences and improving overall academic performance.

Students demonstrated higher engagement and more proactive learning when using the Cornell note-taking system, effectively capturing key course content and structuring information for comprehension. Cornell note-taking proved beneficial as a concise summary tool, a method to encourage active learning, and a strategy for long-term information retention. The approach also supported creativity, as each student was encouraged to develop unique notes reflecting their understanding.
Some students initially faced challenges due to a lack of preparation for note-taking, highlighting the need for guidance and scaffolding in this method. Nevertheless, the Cornell system fostered original reflection, structured note-taking, self-assessment, and collaborative discussion, ultimately enhancing both learning outcomes and critical thinking skills.

4.5 Post-Experiment Assessment and Outcomes

Following the experimental training, students' knowledge, skills, and attitudes were evaluated using multiple measures. Cognitive and skill-based learning outcomes were assessed across six levels of Bloom's taxonomy, while class participation and attitude toward learning were used to gauge affective outcomes. Self-directed learning was also individually evaluated.

Performance metrics included participation scores (max 20), homework scores (max 50), progress test scores (max 30), and overall assessment scores (max 100). Data were analyzed in SPSS using paired-samples t-tests and Spearman correlations, and outcomes were compared with the previous semester's assessments.

The results indicated statistically significant improvements across all measures. Progress test scores increased from M1=22.7M_1 = 22.7M1=22.7 to M2=25.65M_2 = 25.65M2=25.65 (p<.001p < .001p<.001), assignment scores rose from M1=37.85M_1 = 37.85M1=37.85 to M2=46.18M_2 = 46.18M2=46.18 (p<.001p < .001p<.001), and participation scores improved from M1=18.20M_1 = 18.20M1=18.20 to M2=19.85M_2 = 19.85M2=19.85 (p<.001p < .001p<.001) (see Table 9).

These findings indicate that learning activities aligned with students' dominant Felder ILS styles, supplemented by mind mapping, Cornell note-taking, and active-visual instructional strategies, significantly enhanced academic performance, engagement, and self-directed learning.

Table 9. Paired Samples Statistics Analysis of Student Performance Scores (Pretest vs. Posttest)

	N	mean	Std. Deviation	Sig. (2-tailed)
Progress test_1	65	22.74	2.489	0.000
Progress test_2	65	25.65	2.301	
	N	mean	Std. Deviation	Sig. (2-tailed)
Assignment Work _1	65	37.85	8.309	0.000
Assignment Work _2	65	46.18	1.845	
	N	mean	Std. Deviation	Sig. (2-tailed)
Participation_1	65	18.20	2.393	0.000
Participation_2	65	19.85	0.475	

4.6 Correlation between Learning Styles and Overall Performance

Analysis of the relationships between students' Felder ILS learning preferences and their total evaluation scores revealed statistically significant correlations (see Table 10). Specifically, visual–verbal (Vis–Ver, r = .315*), sequential–global (Seq–Glo, r = .580**), sensing–intuitive (Sen–Int, r = .473**), and active–reflective (Act–Ref, r = .460**) learning styles were positively correlated with overall assessment outcomes. These findings indicate that students' learning preferences are meaningfully associated with their academic performance, although the strength of the correlation varies by dimension, with Vis–Ver showing a moderate relationship and the other dimensions showing stronger associations.

Table 10. Spearman's Correlations between Overall Assessment Scores and Felder ILS Learning Styles

		Act/Ref	Sen/Int	Vis/Ver	Seq/Glo	Total
Total	Correlation Coefficient	.460**	.473**	.315*	.580**	1
	Sig. (2-tailed)	0	0	0.011	0	
	N	65	65	65	65	65

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

5. DISCUSSION

This study revealed that, compared with engineering students, education students demonstrate a stronger preference for active and perceptive learning, consistent with the findings of Wang and Mendori [27]. In contrast, Mongolian engineering students exhibited a verbal learning preference, showing greater ability to learn through spoken, written, and explained material, while education students relied more on visual learning strategies.

Engineering students also demonstrated a stronger tendency toward sequential learning, aligning with previous research on developmental traits of Mongolian youth [28]. Overall, engineering students favored Active, Sensing, Verbal, and Sequential styles, whereas education students preferred Active, Sensing, Visual, and Sequential styles. These patterns are comparable to findings from other Asian contexts [19; 29-34].

Mongolian students across disciplines preferred lessons and problems that are practical, real-world, and structured, with a focus on hands-on learning, laboratory exercises, and concrete facts. These results align with Jadamba, Myagmar, and Tuya [35], who reported that Mongolian students aged 11–18 possess well-developed intellectual judgment and social reflection skills shaped by life experiences. Collectively, the findings underscore the importance of aligning instructional strategies with students' discipline-specific learning preferences to enhance engagement, comprehension, and skill development.

The findings indicate that Mongolian students' learning outcomes improved significantly when instructional activities were aligned with their identified learning styles, supporting the view that learning is a dynamic and interactive process rather than a linear transmission of knowledge. From a quantum perspective, this improvement can be explained by increased coherence among learners, instructional design, and the learning environment, allowing learning outcomes to emerge through experiential and relational engagement [1].

6. CONCLUSION

This study demonstrates that the Felder–Soloman Index of Learning Styles (ILS) can effectively guide the selection of instructional strategies tailored to students' individual learning preferences. For the first time in a Mongolian context, the ILS was applied to assess both education and engineering students, enabling the design and implementation of teaching methods aligned with dominant learning styles. Findings indicate that engineering students preferred Active, Sensing, Visual, and Sequential modalities, whereas education students preferred Active, Sensing, Verbal, and Sequential modalities. These preferences suggest that Mongolian students may experience difficulty with abstract, unfamiliar, or poorly structured content, highlighting the importance of practical, clearly structured, and experience-based instructional approaches.

Experimental results confirmed the effectiveness of learning style–aligned instruction. Post-intervention measures showed statistically significant improvements in students' active engagement, homework, and progress test scores ($p < .001$), with average scores increasing from 1.65 to 8.33. The integration of mind mapping, Cornell note-taking, and multimodal teaching resources contributed to these gains, reinforcing both individual and collaborative learning processes.

Overall, the study supports the pedagogical value of adapting teaching strategies to students' preferred learning styles to enhance motivation, comprehension, and performance. Future work should extend this approach across broader courses and disciplines, further exploring the benefits of individualized and cooperative learning for optimizing student outcomes in higher education.

Recent investigations into students' learning styles, complemented by cross-cultural comparative analyses of cognitive profiles, have revealed significant differences in intellectual abilities among students from varied educational contexts, thereby emphasizing the necessity for comprehensive pedagogical approaches that accommodate cultural and cognitive diversity [36].

From a quantum perspective, learning is understood as a multivariate, coherent, and emergent process rather than a linear accumulation of information. This view emphasizes that learning outcomes arise from the simultaneous interaction of multiple variables operating as an integrated system. This study concludes that identifying Mongolian students' learning styles and designing instructional activities aligned with them leads to significantly improved experimental learning outcomes. These findings support the Quantum Approach to teaching and learning by demonstrating that learning outcomes emerge most effectively when coherence is established among the learner, instructional design, and the learning environment [1].

5.1 Acknowledgments

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engagement was invaluable in conducting the study and interpreting the results. We believe that the findings of this study represent a meaningful contribution to the advancement of teaching and learning practices in Mongolia.

5.2 Practical Significance

The findings of this study underscore the importance and feasibility of developing and implementing structured teaching and learning programs that incorporate students' preferred learning styles. Specifically, integrating Quantum teaching methods and other evidence-based instructional strategies into education courses at the Mongolian National University of Education can serve as an effective teaching guide. The study demonstrates that style-aligned instruction enhances student engagement, comprehension, and performance, providing practical guidance for educators seeking to optimize lesson design, select appropriate teaching resources, and foster active, self-directed learning. These insights offer a concrete framework for improving educational outcomes and advancing teaching practices in Mongolian higher education.

5.3 Suggestions for Further Action

Based on the findings of this study, several actionable recommendations can be proposed for educators, curriculum developers, and policymakers:

Integrate learning style assessments: Regularly use tools such as the Felder–Soloman ILS to identify students' learning preferences and tailor instructional strategies accordingly.

Design style-aligned instructional materials: Develop teaching resources (e.g., multimedia, visual aids, hands-on activities) that address diverse learning modalities, including active–reflective, sensing–intuitive, visual–verbal, and sequential–global preferences.

Incorporate evidence-based methods: Embed strategies like mind mapping, Cornell note-taking, flipped learning, and collaborative projects into curricula to support cognitive engagement and enhance comprehension.

Provide professional development for instructors: Train teachers in understanding and applying learning style–aligned methodologies, including how to adapt lessons dynamically to different student groups.

Expand experimental teaching programs: Conduct additional quasi-experimental studies across multiple courses and academic disciplines to refine pedagogical practices and validate the effectiveness of style-aligned instruction in Mongolian higher education.

Foster self-directed learning: Encourage students to recognize their own learning preferences and develop strategies for independent study, critical thinking, and problem-solving.

Monitor and evaluate outcomes: Continuously assess the impact of learning style–aligned instruction on academic performance, engagement, and retention to inform iterative improvements in teaching practice.

Scale to national curriculum development: Consider integrating style-aligned teaching strategies into broader teacher education programs as a guide for enhancing learning outcomes across Mongolia.

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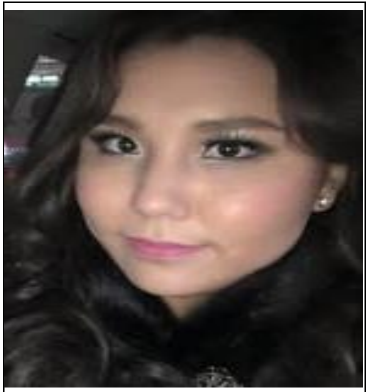

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