Received: 12 May 2026; **Revised:** 01 September 2026; **Accepted:** 07 October 2026; **Published:** 20 November 2026
Archs Sci. (2026) Volume 76, Issue 5 Pages 179-189, Paper ID 2026519.
https://doi.org/10.68304/as/76519

Revitalizing Traditional Chinese Music Education Through the Integration of Modern Pedagogies Within Architectural and Planning Perspectives on Learning Environments

Jing Li
College of Arts, Xiamen University, Xiamen 361005, Fujian, China
Correspondence: chinamusic@xmu.edu.cn

Abstract Traditional Chinese music education faces increasing challenges in preserving cultural heritage while adapting to contemporary pedagogical practices and technological developments. This study investigates an integrated educational framework combining situational teaching, context-aware learning environments, and technology-assisted instructional strategies to enhance student engagement in higher education. The proposed framework incorporates interactive musical activities, contextualized learning experiences, and spatial organization principles to support student-centered instruction. Federated averaging and context-aware computational mechanisms are further considered as potential technological components for distributed music-related learning applications. To evaluate educational effectiveness, a 16-week comparative classroom study was conducted involving an experimental group receiving situational instruction and a control group following conventional teaching methods. Students' music learning interest was assessed at baseline and at four subsequent intervals. The results revealed an overall improvement in both groups, with the experimental group increasing from 2.41 to 4.40 and the control group from 2.40 to 3.75. The corresponding improvements were 1.99 and 1.35 points, respectively, indicating a 0.64-point greater observed increase in the experimental group. Although the control group demonstrated slightly higher scores at Week 4, the experimental group maintained higher learning interest from Week 8 onward.

Index Terms Traditional Chinese music education; Situational teaching; Technology-enhanced learning; Context-aware learning environments; Federated averaging; Student learning interest; Cultural heritage preservation.

I. Introduction

Traditional Chinese music represents an essential component of China's intangible cultural heritage and embodies profound historical, aesthetic, and cultural values. For centuries, traditional music has played a significant role in shaping Chinese cultural identity and artistic expression [1]–[3]. However, with the rapid transformation of educational systems and the increasing influence of globalized music culture, traditional Chinese music education in higher education institutions has faced considerable challenges. In many universities, music curricula increasingly emphasize modern performance techniques and contemporary music theory, while traditional musical forms, instruments, and cultural contexts are gradually marginalized. As a result, revitalizing traditional Chinese music education has become an urgent task in both cultural preservation and educational reform [4].

In recent years, scholars and educators have increasingly recognized that revitalization cannot rely solely on curriculum adjustments or cultural advocacy. Instead, effective revitalization requires the integration of modern pedagogical strategies and innovative learning environments that can stimulate student engagement and facilitate deeper cultural understanding [5], [6]. Modern educational theories, such as constructivist learning theory, experiential learning, and student-centered pedagogy, place particular emphasis on active participation, contextual learning, meaningful practical experience, and collaborative interaction among learners. These approaches have been widely applied in contemporary music education to enhance learning motivation and performance skills. However, the integration of these pedagogical innovations into traditional Chinese music education remains relatively limited [7]–[9]. In many cases, traditional music courses continue to adopt teacher-centered instructional models that emphasize demonstration, repetition, and imitation, potentially reducing students' enthusiasm for sustained study and limiting their opportunities for creative engagement with traditional musical forms [10].

Another critical yet often overlooked dimension in music education reform is the role of the learning environment. Architectural and planning research has increasingly highlighted

the influence of spatial design and environmental context on learning processes and educational outcomes. Characteristics of learning environments, including classroom layout, spatial flexibility, acoustic design, and culturally meaningful contextual settings, can influence student engagement, collaborative learning, and opportunities for creative musical activity [11]. In music education, the learning environment is particularly important because musical performance, ensemble interaction, and embodied practice require specialized spatial conditions. Studies in environmental psychology and educational architecture have demonstrated that well-designed learning spaces can support active learning, collaborative exploration, and contextualized teaching practices [12]. Consequently, examining traditional Chinese music education from an architectural and planning perspective offers a promising pathway for rethinking how learning spaces can support the revitalization of traditional cultural education.

Existing research on music education has primarily focused on pedagogical innovation, curriculum design, and digital learning technologies. For example, situational teaching methods have been widely discussed in educational research as an effective approach to contextualize learning activities and enhance student participation [13]–[15]. Situational learning environments allow students to engage in realistic or culturally meaningful scenarios, thereby connecting theoretical knowledge with practical experience. In the field of music education, situational teaching can involve contextualized performance settings, collaborative ensemble activities, and experiential learning environments that simulate authentic musical practices. Previous studies have reported that situational teaching methods can improve students' learning motivation, creative expression, and practical skills [16], [17].

In addition to pedagogical innovation, recent advances in educational technology have also contributed to the development of intelligent learning environments. Technologies such as context-aware systems, recommendation algorithms, and federated learning frameworks have been explored to support adaptive learning, data-driven instruction, and collaborative knowledge sharing [18]. These computational approaches can assist educators in analyzing student learning behaviors, optimizing instructional strategies, and providing personalized learning support. However, most existing research on technology-assisted music education focuses on digital learning platforms or music information retrieval, while relatively little attention has been given to how computational techniques can be integrated with spatial learning environments and pedagogical design.

Despite these developments, several challenges remain in the revitalization of traditional Chinese music education. First, many current teaching models still rely heavily on conventional lecture-based instruction, which limits students' opportunities for active exploration and cultural immersion. Second, the design of music learning environments in universities often fails to reflect the spatial and contextual characteristics required for traditional musical practices. Standardized classroom layouts may not support interactive performance, ensemble collaboration, or experiential learning activities [19]. Third, although digital technologies and intelligent algorithms have been introduced into educational research, their application in music education is frequently fragmented and lacks integration with pedagogical and spatial design considerations. As a result, there remains a gap between technological innovation, teaching practice, and the architectural design of learning environments.

To address these challenges, this study proposes an integrated framework that combines modern pedagogical approaches with architectural and planning perspectives on learning environments to revitalize traditional Chinese music education. Specifically, the research explores how situational classroom teaching methods can be supported by context-aware learning environments and optimized computational models to enhance teaching effectiveness. By incorporating principles from educational architecture, the study examines how spatial organization, classroom scenarios, and environmental design can facilitate interactive learning and cultural engagement in music education. In addition, computational optimization techniques are employed to support the analysis and improvement of instructional processes within the learning environment [20].

An empirical study was conducted in college-level music education courses to evaluate the effectiveness of the proposed framework. Two groups of students were observed: an experimental group that participated in situational classroom teaching supported by the proposed learning environment framework, and a control group that received conventional instruction. Data on student learning interest, engagement, and teaching outcomes were collected over multiple stages of the teaching process. Through quantitative analysis and comparative evaluation, the study aims to assess whether the integration of modern pedagogies and learning environment design can significantly improve the quality of traditional Chinese music education.

II. Federated Averaging Algorithm Optimization

To examine the possible application of federated learning in music education, a collaborative framework for music transcription and distributed model development is introduced, as illustrated in Figure 1. The framework consists of multiple distributed clients and a central server, where each client represents an independent music learning environment or educational institution. Music-related data, such as audio recordings, musical scores, and transcription annotations, can be processed locally to train individual models without directly transferring the original data to the central server. This distributed structure provides a practical approach to collaborative model development while reducing the need for centralized collection of music education data.

As shown in Figure 1, the server distributes the global model parameters to participating clients, which independently perform local training using their respective music datasets. After local optimization, the updated model parameters are transmitted to the central server for aggrega-

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

tion. The Federated Averaging (FedAvg) algorithm combines these local updates through weighted averaging, where the contribution of each client is determined by the number of its local training samples. The aggregated global model is subsequently redistributed to the participating clients for the next training round. Through iterative local training and global aggregation, the framework enables collaborative optimization across distributed music learning environments. In music education, this mechanism can provide computational support for music transcription, personalized learning assistance, and technology-enhanced instructional activities.

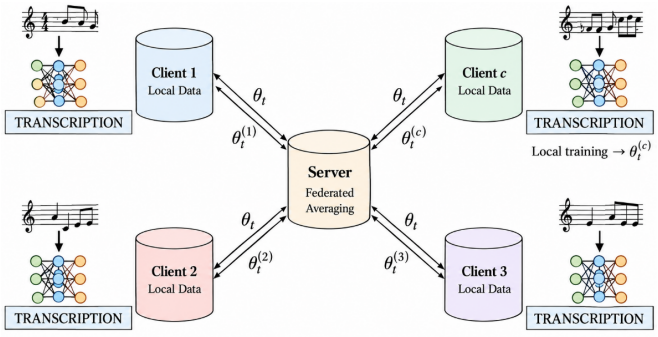


Figure 1: Federated learning framework for collaborative music transcription and model parameter aggregation.

In developing a computational model for music education, federated model training and the averaging of local model parameters require careful specification. The following mathematical representations include Euler angles and quaternions, as introduced in Eq. (1); their relevance to the federated averaging procedure should be established separately in the implementation protocol.

$$q = q_{\theta_1}, q_{\theta_2}, q_{\theta_3} = \left[\cos\frac{\theta_3}{2}, \left(0, 0, \sin\frac{\theta_3}{2}\right)\right] \left[\cos\frac{\theta_2}{2}, \left(0, \sin\frac{\theta_2}{2}, 0\right)\right] \left[\cos\frac{\theta_1}{2}, \left(\sin\frac{\theta_1}{2}, 0, 0\right)\right]. \quad (1)$$

The corresponding rotation matrix is represented by Eq. (2), which expresses the associated orientation transformation in matrix notation.

$$M = \begin{bmatrix} M_{00} & M_{01} & M_{02} \\ M_{10} & M_{11} & M_{12} \\ M_{20} & M_{21} & M_{22} \end{bmatrix} = \begin{bmatrix} 1-2y^2-2z^2 & 2xy-2zw & 2xz+2wy \\ 2xy+2wz & 1-2x^2-2z^2 & 2yz-2wx \\ 2zx-2wy & 2yz+2wx & 1-2x^2-2y^2 \end{bmatrix}. \quad (2)$$

The quaternion is expressed as $q = [\cos(\theta/\rho), n\sin(\theta/\rho)] = [w, (x, y, z)]$, with the component expressions introduced in Eq. (3):

$$\begin{cases} x = \frac{1}{2}\sqrt{M_{00} - M_{11} - M_{22} + 1}, \\ y = \frac{M_{01}+M_{10}}{4x}, \\ z = \frac{M_{02}+M_{20}}{4x}, \\ w = \frac{M_{21}+M_{12}}{4x}. \end{cases} \quad (3)$$

The similarity between motion fragments Q and P is expressed in Eq. (4), using the weighted correspondence between their component representations.

$$\psi(Q, P) = \frac{1}{2}\sum_{i=1}^{k}\left(\left(\frac{\sigma_i}{\sum_{i=1}^{n}\sigma_i} + \frac{\lambda_i}{\sum_{i=1}^{n}\lambda_i}\right)|\mu_i \cdot \nu_i|\right). \quad (4)$$

The objective and constraint functions associated with the presented optimization formulation are defined in Eqs. (5)–(7). Their mathematical interpretation is distinct from the standard federated averaging update rule and requires additional implementation detail.

$$C_j(e_j) = c_j e_j, \qquad S_{ij}(h_{ij}) = s_{ij} h_{ij}, \quad (5)$$

$$I_i(h_i) = \begin{cases} 0, & \sum_j h_{ij} = 1; \\ -\infty, & \text{otherwise}, \end{cases} \quad (6)$$

$$E_j(h_j, e_j) = \begin{cases} 0, & e_j = h_{jj} = \max_i h_{ij} \\ -\infty, & \text{otherwise}. \end{cases} \quad (7)$$

The combined objective function for the clustering formulation is given in Eq. (8), which aggregates the individual similarity and constraint terms.

$$\sum_{i,j} S_{ij}(h_{ij}) + \sum_j \big(C_j(e_j) + E_j(h_j, e_j)\big) + \sum_i I_i(h_i). \quad (8)$$

In this clustering formulation, the constraint functions I and E are intended to assign each point to a unique representative and require a selected exemplar to identify itself accordingly. This constraint-based operation should not be conflated with the averaging of model parameters in federated learning. The hierarchical affinity propagation (HAP) clustering objective is presented in Eq. (9).

$$\sum_{i,j,l} S'_{i,j}(h'_{i,j}) + \sum_{j,l} C^l_j(e^l_j) + \sum_i I^1_i(h^1_i) + \sum_{i,l>1} I^l_i(h^l_{i,j}, e^{l-1}_i) + \sum_{j,l} E^l_j(h^l_{i,j}, e^l_j) \quad (9)$$

Consider two sets of weighted points, as described in Eqs. (10) and (11), with each point associated with a corresponding weight.

$$A = \big\{(A_1, w(A_1)), (A_2, w(A_2)), \mathrm{L}, (A_m, w(A_m))\big\}, \quad (10)$$

$$B = \big\{(B_1, w(B_1)), (B_2, w(B_2)), \mathrm{L}, (B_m, w(B_m))\big\}, \quad A_i, B_j \in \mathbb{R}^2. \quad (11)$$

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

III. Methods

A. Dataset Selection

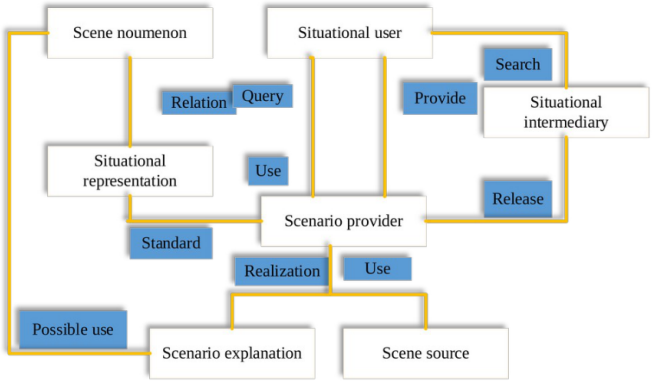


Figure 2: Context-Aware System Framework

This study examines situational classroom teaching in college-level music education and compares the instructional experiences of the experimental and control groups, with particular attention to students' interest in learning traditional Chinese music [21]. As research on context-aware technologies and situational awareness continues to develop, the proposed framework incorporates contextual information about learning activities and classroom conditions. The interrelationships among the principal components of the context-aware system are presented in Figure 2.

The educational population of interest consists of students majoring in music at the college level. The proposed approach combines classroom-based instructional scenarios with computational modeling as a possible means of supporting the development of students' musical understanding, sustained engagement, and practical learning experiences.

Recommendation algorithms serve different instructional and information-management purposes, and their suitability depends on the characteristics of the available data, the intended users, and the learning context. Each approach has identifiable strengths and limitations. Table 1 compares the principal advantages and shortcomings of three representative recommendation strategies.

Table 1: Comparison of Representative Recommendation Algorithms

Recommendation Approach	Advantages	Limitations
Content-Based Recommendation	The results are intuitive and easy to interpret; the method is less dependent on user–item interaction density	Cold-start conditions for new users remain difficult to manage; sufficient information is needed to construct a useful classifier
Collaborative Filtering Recommendation	Can support the recommendation of complex unstructured objects with a high degree of personalization and automation	New-user cold-start difficulties; recommendation quality depends on the available historical interaction data
Association-Rule Recommendation	New items of interest may be identified; the approach can avoid some new-user cold-start limitations	Rule extraction can be difficult and time-consuming; synonymous terms and limited personalization can reduce recommendation quality

Because individual recommendation methods offer different advantages and address different limitations, they can be combined in practice to provide complementary recommendations. This approach is commonly referred to as hybrid recommendation. Two broad strategies are available: combining the outputs obtained from independently applied recommendation algorithms or integrating different recommendation algorithms within a unified recommendation process.

Accordingly, the selection of a hybrid recommendation strategy should be guided by the characteristics of the specific educational environment, the available information, and the intended instructional tasks. Dedicated ontology reasoning systems differ in their supported knowledge-representation languages, implementation requirements, and reasoning capabilities. Representative systems include Pellet, FaCT++, and Jena, and Table 2 compares the listed characteristics of several reasoning engines and related tools.

Table 2: Characteristics of Selected Inference Engines

Inference engine	Jena	Jess	Pellet	Racer	FaCT++
Development Language	Java	Lisp, Java	Java	Lisp	Lisp, C++
Supported Formats	RDF, XML	OWL, SWRL	OWL, RDF, RDFS	OWL, RACER, SWRL	KB
Query Language	SPARQL	RDQL	RDQL	OWL-QL, nRDQL	Not Specified
Sample Code	Available	Available	Available	Not Specified	Not Specified
Implementation Algorithm	Rete	Rete	Tableaux	Tableaux	Tableaux
Database	Available	Not Specified	Not Specified	Available	Not Specified
API	DIG	DIG, Lisp	DIG	DIG, Lisp	DIG
Editor	Protégé	Protégé	Protégé, Oi1Ed	Protégé, Oi1Ed	Protégé, Oi1Ed
Open Source	Yes	Yes	Yes	Commercial	Yes
Developer	HP Labs	Sandia Labs	University of Maryland	Franzens, Germany	University of Manchester

Among the listed tools, Jena is a widely used semantic-web framework with components for the Resource Description Framework (RDF), ontology processing, RDF data models, reasoning functionality, and ontology query languages. The reasoning and ontology subsystems are particularly important elements of the Jena framework [22]. Classroom location scenarios are descriptions of the locations of teachers, students, and classroom administrators. Classroom location scenario information can be divided into two major categories based on the characteristics of student activities: on-campus and off-campus. The specific classroom location scenarios are summarized in Figure 3, which distinguishes on-campus from off-campus activity settings and supports the interpretation of context-aware instructional needs.

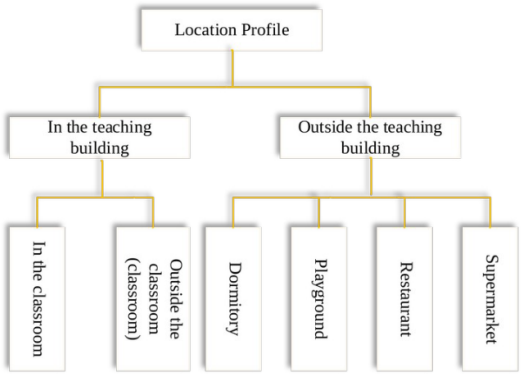


Figure 3: Classification of Classroom Location and Context Information

The situational classroom differs from conventional instructor-led music teaching in its pedagogical orientation, organization of learning activities, and emphasis on contextual participation. It represents a distinct instructional approach rather than a simple adjustment to the presentation of existing

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

course content. A central consideration when applying situational classroom methods to college music education is how effectively they support students' independent learning. Introductory study of musical materials, performance techniques, and relevant concepts can take place before class, while classroom sessions can focus on problems identified during prior study, guided practice, collaborative performance, and discussion, thereby supporting more purposeful use of instructional time [23].

B. Federated Learning Model Training and Optimization

The motivation for using multiple classifiers is to improve the reliability of computational predictions and reduce the potential for overfitting to individual training samples. The conceptual sequence of optimization and aggregation operations is illustrated in Figure 4, although the implementation and validation procedures require separate documentation.

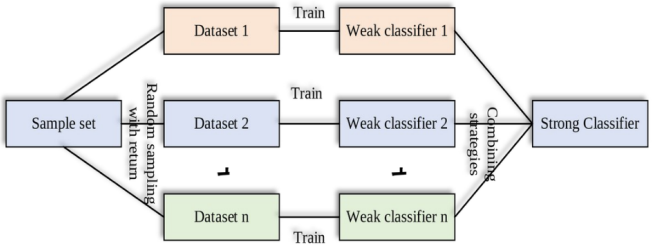


Figure 4: Optimization Flowchart for the Federated Averaging Framework

Figure 5 illustrates the conceptual model-training process associated with federated reinforcement learning. The schematic should be distinguished from an experimentally validated implementation of the proposed instructional system.

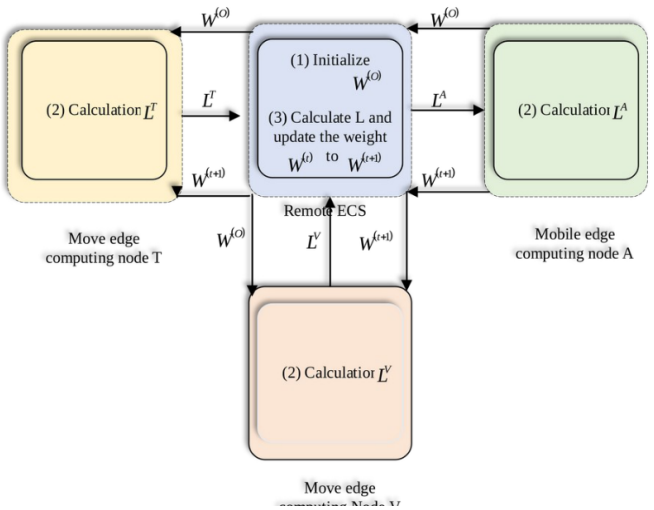


Figure 5: Model Optimization Using Federated Reinforcement Learning

Within this model, the configuration of neurons across successive network layers and the characteristics of the available datasets may influence optimization and the balance of parameter updates. Consequently, appropriate normalization and aggregation procedures must be considered when coordinating local models. The relevant weighting and averaging expressions are presented in Eqs. (12) and (13); their parameter definitions and empirical implementation should be stated explicitly.

$$\mathrm{att}_k^l = \mathrm{softmax}\big(\|w' - w_k^l\|_p\big) = \frac{e^{\|w'-w_k^l\|_p}}{\sum_{k=1}^{n} e^{\|w'-w_k^l\|_p}}, \tag{12}$$

$$w^L = \frac{w_a^L + \cdots + w_b^L}{K}. \tag{13}$$

This subsection describes the database management structure and the principal database tables required for the proposed system's implementation. These include the teacher information table in Table 3, the student information table in Table 4, and the curriculum schedule table in Table 5, which together support the system's administrative and instructional functions.

Table 3: Teacher Information Table for the Situational Music Education System

Field Name	Data Type	Length	Allows Null	Field Description
Id	Int	11	No	Primary key, teacher serial number
Name	Varchar	10	Yes	Teacher Name
Username	Varchar	20	Yes	Teacher user name
Password	Varchar	20	Yes	Teacher password
Qx	Int	11	Yes	Teacher authority
Remark	Varchar	255	Yes	Remarks

Table 4: Student Information Table for the Situational Music Education System

Field Name	Data Type	Length	Allows Null	Field Description
Id	Int	11	No	Primary key, student serial number
Cid	Int	11	No	Class No
Sno	Varchar	20	No	Student ID
Password	Varchar	20	No	Password
Name	Varchar	10	Yes	Student Name
Sex	Varchar	10	Yes	Student gender
Phone	Varchar	20	Yes	Student contact information
Remark	Varchar	255	Yes	Remarks

Table 5: Curriculum Schedule Table for the Situational Music Education System

Field Name	Data Type	Length	Allows Null	Field Description
Id	Int	11	No	Primary key, course serial number
Teacherid	Int	11	No	Teacher serial number
Classid	Int	11	No	Class No
Name	Varchar	20	No	Course name
AttendNum	Int	11	Yes	Attendance count
TaskNum	Int	11	Yes	Number of people submitting work
Remark	Varchar	255	Yes	Remarks

The database is designed to provide fundamental data support for the operation of the college music education scenario-based classroom system. It mainly consists of teacher information, student information, and curriculum schedule tables. The

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

teacher table stores teacher identifiers, login-related fields, and permission information, while the student table records students' basic information, class affiliations, and system login data. The curriculum schedule table establishes the association among teachers, classes, and courses through teacher and class identifiers, and further records classroom participation and task-submission information. Through these interconnected tables, the system can support user authentication, teacher and student management, class organization, course scheduling, attendance-related statistics, and learning-task management. Overall, the database provides a structured data foundation for the implementation and operation of the scenario-based music education classroom system.

IV. Experimental Evaluation and Results

A. Research Objectives and Evaluation Framework

The experimental evaluation investigates whether a situational learning environment incorporating modern pedagogical approaches can support the revitalization of traditional Chinese music education in higher education. Particular attention is given to the development of students' learning interest over time and the potential contribution of technology-assisted instructional support.

The evaluation is organized around two complementary components. The first is a longitudinal classroom comparison examining changes in students' music learning interest under situational and conventional teaching conditions. The second concerns the computational framework introduced in Section 2, in which distributed music-related information can be processed through federated model training and parameter aggregation [24].

The distinction between these components is important. Improvements in learning interest do not, by themselves, establish the effectiveness of the federated learning algorithm. Similarly, gains in computational accuracy cannot be interpreted as evidence of improved music education unless a measurable relationship between the technical system and learning outcomes is demonstrated.

Three research questions guide the evaluation:

RQ1: How does students' music learning interest change over a 16-week period under situational classroom teaching compared with conventional instruction?

RQ2: To what extent can the observed learning trajectories be associated with changes in pedagogical practice and the organization of the music learning environment?

RQ3: What additional computational evidence is required to establish whether federated learning contributes to music-related instructional tasks?

The existing longitudinal classroom data provide descriptive evidence relevant to RQ1. RQ2 requires more detailed documentation of the intervention and classroom conditions, whereas RQ3 requires a separately reproducible computational evaluation.

B. Classroom Study Design and Experimental Setting

1) Study Design And Participants

The classroom evaluation followed a two-group longitudinal comparative design involving students enrolled in college-level music education courses. One group participated in situational classroom teaching, whereas the comparison group received conventional instruction.

The intervention was evaluated over 16 weeks, with learning interest recorded at baseline and at Weeks 4, 8, 12, and 16. This repeated-measurement structure permits a descriptive examination of the direction, timing, and magnitude of changes across successive stages of classroom instruction and engagement with traditional music.

The available study documentation identifies an experimental class and a control class but does not specify the number of participating students, the recruitment procedure, eligibility criteria, group allocation mechanism, or attrition.

2) Situational Music Learning Environment

The experimental intervention was developed around the principle that traditional music education should integrate technical learning, musical experience, and cultural understanding. Rather than treating musical knowledge solely as content transmitted by the instructor, situational teaching emphasizes the relationship between learning activities and meaningful musical contexts.

Within this pedagogical framework, the learning environment is expected to support active participation, collaborative musical practice, contextual interpretation, and student-centered feedback. Activities may include the interpretation of traditional musical materials, contextualized performance practice, collaborative ensemble learning, and reflection on the cultural significance of musical works.

The spatial dimension of this framework concerns the extent to which classroom arrangements and instructional resources accommodate these activities. Relevant environmental characteristics include the flexibility of the teaching space, the configuration of individual and group practice areas, access to musical instruments and digital resources, and opportunities for interaction between students and instructors.

These elements define the intended intervention framework; however, the available experimental record does not specify which individual spatial or instructional components were implemented in each teaching session.

3) Conventional Teaching Condition

The control condition represents the conventional music teaching approach described in the original study. This approach primarily emphasizes instructor explanation, musical demonstration, imitation, and repeated practice.

Such teaching provides an established reference for comparing students' learning experiences with those associated with situational instruction. However, conventional music instruction may also incorporate interactive and practical activities. Therefore, the comparison should not be interpreted as

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

a contrast between completely passive and completely active learning without supporting classroom observation.

The instructional content, learning objectives, teaching duration, access to instruments, and assessment requirements should be documented for both groups to determine whether observed differences could be associated with factors other than the situational learning environment.

C. Outcome Measures And Data Collection

1) Primary Outcome: Music Learning Interest

Music learning interest was defined as the primary educational outcome for evaluating the effectiveness of the proposed situational teaching framework. The evaluation focused on students' engagement with musical learning activities, their motivation to participate in classroom instruction, and their sustained interest in musical knowledge and performance practice.

Musical score materials, including multi-part ensemble notation and single-melody excerpts, were considered potential instructional stimuli for organizing structured music learning tasks. As illustrated in Figure 6, these materials provide examples of different notation structures that can support score reading, melodic analysis, rhythmic interpretation, and collaborative performance activities. Their use in the present study, however, must be verified against the original instructional records.



Figure 6: Examples of Musical Notation Materials for Score Reading and Performance-Oriented Learning Activities

The primary outcome was assessed using music learning interest scores recorded at five measurement points: baseline and Weeks 4, 8, 12, and 16. These measurements were intended to characterize longitudinal changes in students' interest under the situational teaching and conventional teaching conditions.

Let $Y_{i,t}$ represent the music learning interest score of student (i) at measurement time (t). The mean score for group (g) at time (t) is defined as:

$$\overline{Y}_{g,t} = \frac{1}{N_{g,t}} \sum_{i=1}^{N_{g,t}} Y_{i,t}, \tag{14}$$

where $N_{g,t}$ denotes the number of students with valid observations in group (g) at time (t).

The observed change in the group mean from baseline to Week 16 is calculated as:

$$\Delta_g = \overline{Y}_{g,16} - \overline{Y}_{g,0}. \tag{15}$$

The between-group difference in observed changes is then expressed as: $\Delta_{\text{experimental}} - \Delta_{\text{control}}$.

Based on the available experimental records, the experimental group's mean music learning interest score increased from 2.41 at baseline to 4.40 at Week 16, whereas the control group's mean score increased from 2.40 to 3.75. These values correspond to observed changes of 1.99 and 1.35 score units, respectively, producing a between-group difference in changes of 0.64 score units.

D. Results of the Longitudinal Music Learning Interest Evaluation

Table 6 presents the music learning interest results for the experimental and control conditions over the 16-week teaching period.

Table 6: Reported music learning interest scores across the 16-week classroom comparison

Measurement stage	Experimental group	Control group	Mean difference (Exp. − Ctrl.)
Baseline	2.41 (0.25)	2.40 (0.28)	+0.01
Week 4	3.35 (0.25)	3.50 (0.21)	−0.15
Week 8	3.76 (0.53)	3.43 (0.27)	+0.33
Week 12	3.91 (0.47)	3.59 (0.38)	+0.32
Week 16	4.40 (0.31)	3.75 (0.26)	+0.65

At baseline, the two groups exhibited nearly identical mean learning interest scores, with values of 2.41 and 2.40 for the experimental and control groups, respectively. The initial between-group difference was only 0.01 score units. After four weeks of classroom instruction, both groups showed higher average learning interest scores than at baseline. The control group reached 3.50, compared with 3.35 in the experimental group. Thus, the experimental condition did not demonstrate an advantage at the first follow-up.

The relative ordering of the groups changed at Week 8. The experimental group achieved a mean score of 3.76, compared with 3.43 in the control group, representing a between-group difference of 0.33 score units. At Week 12, the corresponding mean scores were 3.91 and 3.59, resulting in a difference of 0.32 score units. By Week 16, the experimental group's mean learning interest score had increased to 4.40, whereas the control group's mean score was 3.75. The between-group difference at the final measurement was therefore 0.65 score units.

Taken together, these descriptive observations indicate an overall upward learning-interest trajectory in both groups, with a larger observed improvement in the experimental group after the initial four-week period. The available summary scores, however, do not establish the causal contribution of any particular classroom design feature.

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

Figure 7 presents a comparative analysis of students' music learning interest under the proposed situational teaching approach and conventional classroom instruction over a 16-week period. As illustrated in Figure 7(a), both groups exhibited an overall increase in learning interest, with the experimental group improving from 2.41 at baseline to 4.40 at Week 16, compared with an increase from 2.40 to 3.75 in the control group. Figure 7(b) further demonstrates the evolution of between-group differences, revealing a slight advantage for the control group at Week 4 (-0.15), followed by consistently higher scores in the experimental group from Week 8 onward, with the difference reaching 0.65 at the final assessment. As shown in Figure 7(c), the experimental group achieved an overall improvement of 1.99 points, exceeding the 1.35-point increase observed in the control group by 0.64 points. Furthermore, Figure 7(d) highlights the higher final learning interest score achieved under the situational teaching condition. These findings suggest that integrating contextualized instructional activities, interactive learning experiences, and technology-supported teaching environments may contribute to sustaining students' interest in traditional Chinese music education. From the perspective of educational environment design, the observed learning trajectories are consistent with the potential benefits of student-centered and experiential pedagogical approaches.

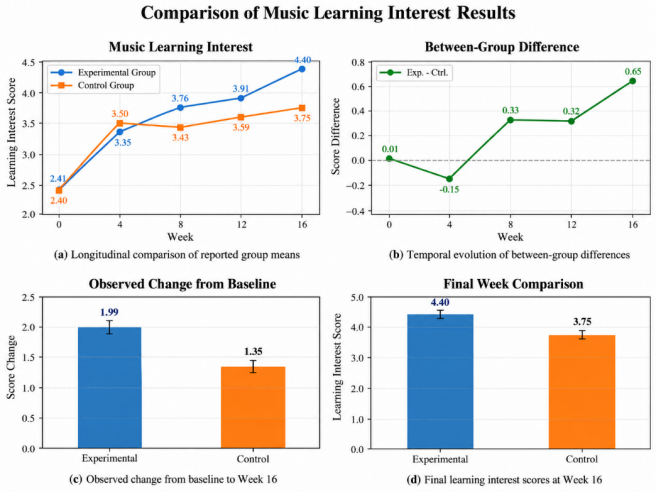


Figure 7: Comparative Analysis of Music Learning Interest Under Situational and Conventional Teaching

Figure 8 illustrates the variation in spatial localization errors under different measurement configurations within the proposed context-aware music learning environment. The results reveal noticeable differences in positioning errors across measurement settings, with relatively low errors observed under certain configurations and larger deviations approaching 1.0 under others. These variations indicate that localization performance is sensitive to the measurement configuration, highlighting the importance of optimizing spatial information acquisition in technology-enhanced music classrooms. Within the proposed framework, reliable localization can facilitate the identification of classroom activity locations, the coordination of interactive music learning activities, and the provision of context-aware instructional resources. Furthermore, the integration of spatial localization with situational teaching provides a potential technical foundation for establishing flexible and interactive learning environments that support traditional Chinese music education. Nevertheless, the observed results primarily characterize localization behavior and do not independently demonstrate improvements in students' musical proficiency or learning motivation.

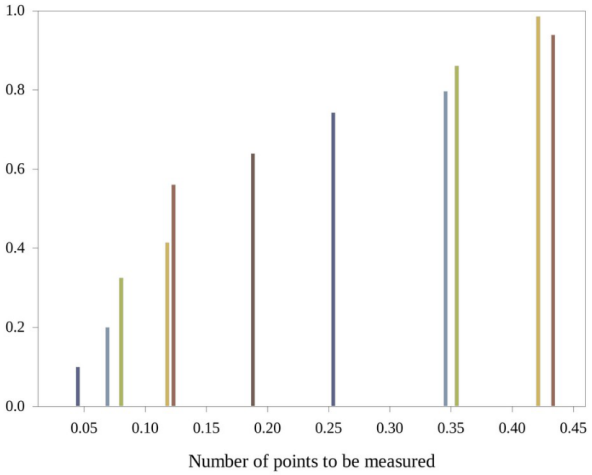


Figure 8: Localization Errors Under Different Measurement Configurations in the Context-Aware Music Learning Environment

Figure 9 presents a comparative analysis of the localization error distributions obtained using the proposed optimized algorithm and the conventional VIRE method within the context-aware music learning environment. As illustrated in the figure, the optimized algorithm exhibits a left-shifted stepwise curve compared with the conventional VIRE method, suggesting lower localization errors at comparable cumulative probability levels when the results are interpreted as error cumulative distribution functions (CDFs). This observation indicates the potential effectiveness of the optimization strategy in improving spatial positioning accuracy, which is relevant to the development of intelligent and interactive music learning environments. Within the proposed traditional Chinese music education framework, improved localization capabilities could facilitate the identification of classroom activity areas, the coordination of collaborative musical practices, and the context-aware delivery of instructional resources. Furthermore, integrating reliable spatial information with situational teaching may provide technical support for creating flexible and responsive educational environments that encourage student participation and experiential learning.

Table 7 presents the longitudinal changes in students' music learning interest across five measurement stages over the 16-week teaching intervention. At baseline, the experimental and control groups exhibited comparable mean interest scores of 2.41 and 2.40, respectively, indicating a minimal initial

ARCHIVES DES SCIENCES
A Multidisciplinary Journal

difference in the measured outcome. After four weeks, both groups demonstrated increased learning interest, although the control group achieved a slightly higher score (3.50) than the experimental group (3.35). However, this pattern reversed at Week 8, when the experimental group reached 3.76 compared with 3.43 in the control group. The experimental group maintained higher scores throughout the subsequent measurement stages, reaching 3.91 at Week 12 and 4.40 at Week 16, whereas the corresponding control group scores were 3.59 and 3.75. Over the entire intervention period, the experimental group demonstrated an increase of 1.99 points, compared with 1.35 points in the control group, yielding a between-group difference in observed changes of 0.64 points. These longitudinal patterns suggest that the integration of situational teaching strategies and interactive learning activities may be associated with greater improvements in students' interest in traditional Chinese music education.

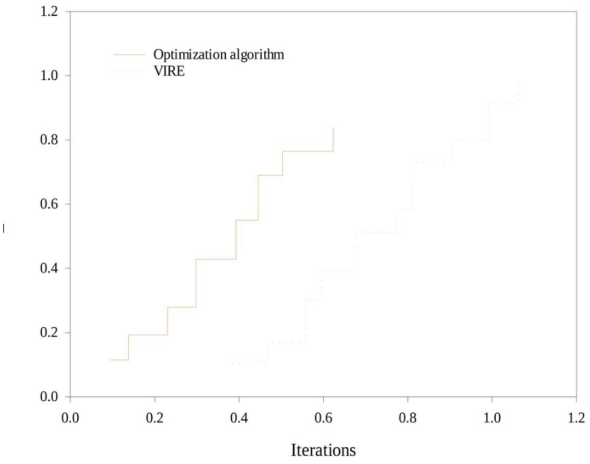


Figure 9: Localization Error Distributions for the Optimized Algorithm and VIRE

Table 7: Music Learning Interest Results for Experimental and Control Classes

Measurement	Experimental Class	Control Class	Difference	Reported P
Baseline	2.41 ± 0.25	2.40 ± 0.28	+0.01	>0.05
Week 4	3.35 ± 0.25	3.50 ± 0.21	−0.15	>0.05
Week 8	3.76 ± 0.53	3.43 ± 0.27	+0.33	<0.01
Week 12	3.91 ± 0.47	3.59 ± 0.38	+0.32	<0.01
Week 16	4.40 ± 0.31	3.75 ± 0.26	+0.65	<0.01

Figure 10 illustrates the temporal evolution of learning outcomes between the experimental and control groups under different instructional approaches. Both groups exhibit comparable performance during the initial stage, suggesting similar starting conditions. Following the introduction of the situational teaching approach, the experimental group demonstrates a progressively increasing trajectory, eventually surpassing the control group and maintaining a higher performance level throughout the later stages. In contrast, the control group exhibits relatively limited improvement and noticeable fluctuations, indicating a less consistent progression under conventional instruction. These differences suggest that integrating contextualized learning activities, interactive instructional strategies, and technology-supported educational environments may contribute to sustained student engagement and improved learning experiences. Within the proposed framework for revitalizing traditional Chinese music education, the observed trend is consistent with the potential benefits of combining modern pedagogical approaches with adaptive learning environments to encourage active participation and musical exploration.

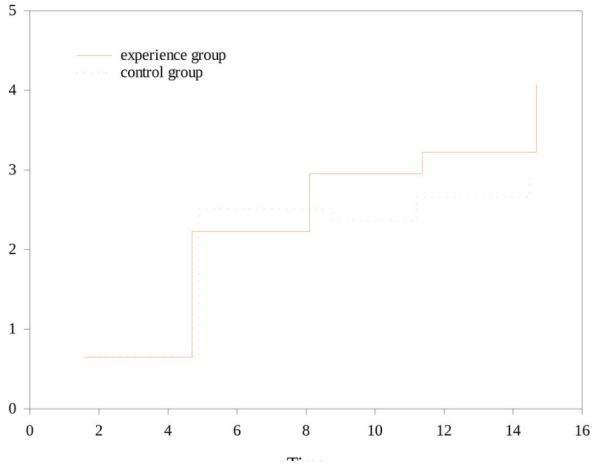


Figure 10: Changes in Music Learning Interest Over the 16-Week Teaching Period

E. Interpretation, Robustness, and Limitations

The principal empirical observation is that students in the situational teaching condition showed a greater mean increase in reported music learning interest than those in the conventional teaching condition.

This finding is compatible with educational theories emphasizing contextual engagement, active participation, and experiential learning. Situational instruction may provide students with opportunities to relate musical techniques to meaningful artistic and cultural contexts, potentially supporting sustained engagement with traditional Chinese music.

However, several limitations restrict the interpretation of the available results.

First, the absence of documented group allocation and baseline participant characteristics prevents a reliable assessment of selection bias. The number of independent classrooms is particularly important because classroom effects may be confounded with instructional conditions.

Second, the learning interest instrument is insufficiently described. Without information about measurement reliability, scale characteristics, and item-level validity, it is difficult to establish whether the reported changes represent comparable and meaningful developments in the intended psychological construct.

Third, the classroom intervention lacks the operational detail required for independent replication. The contributions of contextual teaching, interactive activities, technological

support, and physical learning environment design cannot currently be disentangled.

Fourth, the evaluation relies primarily on learning interest. Interest is educationally important but should not be used as a substitute for demonstrated improvement in musical proficiency, cultural understanding, or performance quality.

Fifth, the computational system has not been evaluated using sufficiently documented music-domain experiments. The available evidence does not permit confirmation of an accuracy improvement attributable to federated model optimization.

Finally, the study does not establish a direct causal pathway from federated computation or architectural design to improved educational outcomes.

These limitations do not invalidate the descriptive learning trajectories. Instead, they define the scope of the claims that can reasonably be supported.

V. Conclusion

This study investigated the revitalization of traditional Chinese music education through the integration of modern pedagogies within architectural and planning perspectives on learning environments. By combining situational classroom teaching with context-aware learning environments and computational support, the research aimed to enhance student engagement and teaching effectiveness in college music education. The available empirical results indicate that students experiencing situational instruction showed a larger descriptive increase in music learning interest than students receiving conventional teacher-centered instruction. The source manuscript also reports an approximately 8% improvement in computational evaluation accuracy; however, reproducible model settings, sample-level results, and an independently documented comparison are required before this technical improvement can be confirmed.

From an architectural and planning perspective, the findings highlight the importance of learning environment design in supporting innovative teaching methods. Flexible classroom spaces, contextual learning settings, and interactive spatial arrangements can facilitate collaborative learning and experiential engagement in music education. Such environments not only enhance teaching effectiveness but also provide meaningful contexts for the transmission of traditional musical culture.

Conflicts of Interest

The author declares that there are no known financial or non-financial conflicts of interest.

Funding Statement

The author reports that no specific external funding was received to support the research presented in this manuscript.

Data Availability

The data used to support the findings reported in this study are available from the author upon reasonable request.

References

[1] Fang, L., & Luen, L. C. (2024). Innovative teaching approaches and student motivation in music education at Shangrao University, China. *International Journal of Academic Research in Progressive Education and Development, 13*(1), 2067–2074. https://doi.org/10.6007/IJARPED/v13-i1/20793

[2] Jiang, M. (2025). The optimization of curriculum system for music education professionals in the inheritance and transmission of intangible cultural heritage music. *Pacific International Journal, 8*(2), 139–146. https://doi.org/10.55014/pij.v8i2.801

[3] Long, Z., Yap, J. H., & Imam Koning, S. (2024). Harmonising tradition and technology: A review of multimedia integration in Guizhou's vocal music. *Asian Pendidikan, 4*(1), 14–22. https://doi.org/10.53797/aspen.v4i1.2.2024

[4] Xu, J., He, H., & Song, C. (2024). Analysis and design of digital transformation factors in the teaching process of the "wise traditional music classroom." *Lecture Notes in Education Psychology and Public Media, 35*, 142–150. https://doi.org/10.54254/2753-7048/35/20232082

[5] Salomon, G. (2016). It's not just the tool but the educational rationale that counts. In E. Elstad (Ed.), *Educational technology and polycontextual bridging* (pp. 149–161). SensePublishers. https://doi.org/10.1007/978-94-6300-645-3_8

[6] Yin, L., & Guo, R. (2025). An artificial intelligence-based interactive learning environment for music education in China: Traditional Chinese music and its contemporary development as a way to increase cultural capital. *European Journal of Education, 60*(1), Article e12858. https://doi.org/10.1111/ejed.12858

[7] Inkinen, J., Klager, C., Schneider, B., Juuti, K., Krajcik, J., Lavonen, J., & Salmela-Aro, K. (2019). Science classroom activities and student situational engagement. *International Journal of Science Education, 41*(3), 316–329. https://doi.org/10.1080/09500693.2018.1549372

[8] Dong, Y., Yin, H., Du, S., & Wang, A. (2021). The effects of flipped classroom characterized by situational and collaborative learning in a community nursing course: A quasi-experimental design. *Nurse Education Today, 105*, Article 105037. https://doi.org/10.1016/j.nedt.2021.105037

[9] Kayima, F., & Jakobsen, A. (2020). Exploring the situational adequacy of teacher questions in science classrooms. *Research in Science Education, 50*(2), 437–467. https://doi.org/10.1007/s11165-018-9696-9

[10] Yao, L., Sensai, P., & Junkate, K. (2023). Nurturing cultural engagement and learning among youth through Jingyun Dagu traditional Chinese folk songs in Tianjin Municipality. *International Journal of Curriculum and Instruction, 15*(3), 1845–1859.

[11] Talbert, R., & Mor-Avi, A. (2019). A space for learning: An analysis of research on active learning spaces. *Heliyon, 5*(12), Article e02967. https://doi.org/10.1016/j.heliyon.2019.e02967

[12] de Borba, G. S., Alves, I. M., & Campagnolo, P. D. B. (2020). How learning spaces can collaborate with student engagement and enhance student-faculty interaction in higher education. *Innovative Higher Education, 45*(1), 51–63. https://doi.org/10.1007/s10755-019-09483-9

[13] Rands, M. L., & Gansemer-Topf, A. M. (2017). The room itself is active: How classroom design impacts student engagement. *Journal of Learning Spaces, 6*(1), 26–33.

[14] Odum, M., Meaney, K. S., & Knudson, D. V. (2021). Active learning classroom design and student engagement: An exploratory study. *Journal of Learning Spaces, 10*(1), 27–42.

[15] Zhang, A., Gong, Y., Chen, Q., Jin, X., Mu, Y., & Lu, Y. (2025). Driving innovation and sustainable development in cultural heritage education through digital transformation: The role of interactive technologies. *Sustainability, 17*(1), Article 314. https://doi.org/10.3390/su17010314

[16] Pöysä, S., Vasalampi, K., Muotka, J., Lerkkanen, M.-K., Poikkeus, A.-M., & Nurmi, J.-E. (2019). Teacher–student interaction and lower secondary school students' situational engagement. *British Journal of Educational Psychology, 89*(2), 374–392. https://doi.org/10.1111/bjep.12244

[17] Liang, K., Hao, Y., & Zhao, J. (2021). An empirical study on the effect and quality of situational English teaching. *International Journal of Emerging Technologies in Learning, 16*(21), 74–86. https://doi.org/10.3991/ijet.v16i21.26863

[18] Inkinen, J., Klager, C., Juuti, K., Schneider, B., Salmela-Aro, K., Krajcik, J., & Lavonen, J. (2020). High school students' situational engagement associated with scientific practices in designed science learning situations. *Science Education, 104*(4), 667–692. https://doi.org/10.1002/sce.21570

[19] Wang, Y., & Zheng, G. (2020). Application of artificial intelligence in college dance teaching and its performance analysis. *International Journal of Emerging Technologies in Learning, 15*(16), 178–190. https://doi.org/10.3991/ijet.v15i16.15939

[20] McMahan, H. B., Moore, E., Ramage, D., Hampson, S., & Agüera y Arcas, B. (2017). Communication-efficient learning of deep networks from decentralized data. In *Proceedings of the 20th International Conference on Artificial Intelligence and Statistics* (Proceedings of Machine Learning Research, Vol. 54, pp. 1273–1282). PMLR.

[21] Gui, D. (2025). Construction of a dynamic teaching model for traditional Chinese music integrated with artificial intelligence. *Journal of Anhui University of Technology (Social Sciences), 42*(3), 72–74, 78. https://doi.org/10.3969/j.issn.1671-9247.2025.03.021

[22] Carroll, J. J., Dickinson, I., Dollin, C., Reynolds, D., Seaborne, A., & Wilkinson, K. (2004). Jena: Implementing the Semantic Web recommendations. In *Proceedings of the 13th International World Wide Web Conference on Alternate Track Papers & Posters* (pp. 74–83). Association for Computing Machinery. https://doi.org/10.1145/1013367.1013381

[23] Zhang, C., Xie, Y., Bai, H., Yu, B., Li, W., & Gao, Y. (2021). A survey on federated learning. *Knowledge-Based Systems, 216*, Article 106775. https://doi.org/10.1016/j.knosys.2021.106775

[24] Kairouz, P., McMahan, H. B., Avent, B., Bellet, A., Bennis, M., Bhagoji, A. N., Bonawitz, K., Charles, Z., Cormode, G., Cummings, R., D'Oliveira, R. G. L., Eichner, H., El Rouayheb, S., Evans, D., Gardner, J., Garrett, Z., Gascón, A., Ghazi, B., Gibbons, P. B., … Zhao, S. (2021). Advances and open problems in federated learning. *Foundations and Trends in Machine Learning, 14*(1–2), 1–210. https://doi.org/10.1561/2200000083