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Arts Education in a Digital Society: National Evidence on Participation and Community Engagement

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ABSTRACT: The convergence of artistic practice and digital technology has expanded opportunities for learning, creative production, cultural access, and community participation, yet nationally representative evidence connecting these domains remains limited. This study develops and tests a multidisciplinary framework linking arts education, digital arts engagement, visual and performing arts creation, and community involvement. We also conducted a secondary cross-sectional analysis using the 2022 Survey of Public Participation in the Arts supplement to the Current Population Survey. We linked public-use person records to 160 replicate weights, yielding 13,251 eligible adults and four randomized module-pair samples ranging from 3,091 to 3,228 respondents. Design-weighted prevalence estimates and replicate-weighted logistic regressions adjusted for age, sex, educational attainment, race and ethnicity, household income, employment, disability, and region. School-based arts education was associated with substantially higher odds of digital arts engagement (adjusted odds ratio 3.57, 95% confidence interval 2.59-4.94) and artistic creation or performance (3.41, 2.69-4.31). Digital arts engagement was also associated with community participation (3.16, 2.20-4.54), while artistic creation showed a comparably strong association (3.44, 2.62-4.50). The findings support a pathway in which arts learning connects to later digital and creative participation, which in turn links to broader community engagement. Because the evidence is cross-sectional and split across randomized modules, the results establish population-level associations rather than causal effects. The study contributes an empirically grounded framework for educators, cultural institutions, and policymakers seeking to connect visual and performing arts, digital inclusion, and community development.

Keywords: arts education; digital arts participation; visual arts and performing arts; cultural participation; community engagement.

I. INTRODUCTION

Visual and performing arts occupy a distinctive position at the intersection of education, technology, culture, and social development. They are simultaneously forms of knowledge, practices of expression, modes of communication, and infrastructures of participation. In schools and universities, artistic activity can support observation, interpretation, disciplined practice, collaboration, and reflective judgment. In museums, theatres, cultural centers, and community settings, it can create shared experiences that help people encounter unfamiliar perspectives, negotiate identity, and participate in public life. Digital technologies have broadened these functions by enabling remote access, multimedia interpretation, networked creation, online circulation, and hybrid forms of performance.

This expansion, however, does not mean that technology automatically strengthens arts education or social development. Digital access is uneven, creative opportunities remain socially stratified, and online exposure may not translate into active creation or community participation. A person may view cultural content on a

device without developing artistic skills, sharing creative work, volunteering, attending community events, or supporting cultural organizations. The central research problem is therefore not whether art and technology coexist, but how educational experience, digital participation, creative practice, and civic involvement are connected within a wider social system.

Existing research is often organized into separate fields. Arts education studies examine learning, critical thinking, and creative skill. Digital-learning research evaluates augmented, mobile, or immersive environments. Cultural-participation research considers attendance, production, and inequalities in access. Community arts scholarship focuses on connectedness, belonging, wellbeing, and social capital. These traditions provide important evidence, yet their separation makes it difficult to evaluate a complete pathway from arts learning to technologically mediated engagement, from engagement to creation, and from creation to community participation.

A multidisciplinary framework is especially valuable because visual and performing arts cannot be reduced to a single activity. Visual art includes painting, photography, film, craft, design, and digitally produced imagery. Performing arts include music, singing, dance, acting, and theatre. Digital participation may involve viewing or listening, posting about artistic content, using devices in performance, producing digital art, or sharing creative work online. Community development may appear through volunteering, local events, cultural support, and other participation that strengthens social relationships. A rigorous study must therefore distinguish these dimensions while examining their interconnections.

The present study uses nationally representative public-use microdata to move the topic from a broad conceptual claim to an empirical population analysis. The survey structure is particularly suitable because it separates electronic arts participation, artistic creation and performance, arts-related civic activity, and arts education into randomized modules. This design does not permit every construct to be observed for every respondent, but it enables four valid module-pair analyses that correspond to the proposed framework. Replicate weights further allow uncertainty to be estimated in a manner consistent with the complex survey design.

The study does not interpret cross-sectional association as proof of causation. Prior interests, family resources, educational opportunity, cultural exposure, and local institutional conditions may influence both arts learning and later participation. The analysis therefore adjusts for a broad set of demographic and socioeconomic characteristics and uses robustness tests, while retaining cautious language about direction and mechanism. The intended outcome is a defensible empirical framework that can inform future longitudinal, institutional, and intervention-based research.

II.LITERATURE REVIEW

Augmented-reality scholarship has clarified both the opportunities and limitations of technology-supported learning. A systematic review identified motivation, visualization, and interactivity as recurring advantages, while also documenting usability problems, technical instability, and cognitive-load concerns [1]. Research on cultural heritage extended this discussion by mapping applications of augmented, virtual, and mixed reality in reconstruction, preservation, visualization, and interpretation [2]. Museum-based art-therapy activities have also been shown to promote social connectedness and psychological wellbeing among older adults [3].

Foundational research established important interaction requirements for augmented environments, including tracking, display quality, usability, and close alignment between the interface and the user's task [4]. A randomized visual-art field experiment demonstrated that structured museum exposure can strengthen students' critical interpretation of unfamiliar artworks [5]. Research on choral singing further connected artistic participation with affective states, social connectedness, and stress-related processes, indicating both relational and psychobiological effects [6].

Participatory arts have been presented as a potential means of addressing loneliness by strengthening belonging, self-worth, and reciprocal relationships [7]. A qualitative systematic review further identified trust, networks, reciprocity, and access to shared resources as central social-capital mechanisms in

participatory arts programs [8]. Longitudinal population evidence also showed that sustained cultural engagement is associated with more favorable cognitive trajectories among older adults [9].

A graded longitudinal association has been reported between cultural engagement and a lower subsequent risk of depression among older adults [10]. A meta-analysis found positive average learning effects for augmented reality, although the magnitude of these effects varied substantially according to the learning environment, learner characteristics, and implementation quality [11]. Museum-based research also showed that augmented content can influence attention, experiential value, and behavioral responses [12].

A systematic review concluded that augmented reality is most educationally useful when integrated with a clear instructional strategy and evaluated through measurable learning outcomes [13]. Research on wearable interpretation in art galleries found that digital prompts can support learning when they remain closely connected to the artwork and the visitor's interpretive task [14]. Evidence on digital cultural participation demonstrated that online engagement remains socially stratified, indicating that expanded digital access does not eliminate inequalities in resources, skills, or participation [15].

Traditional and electronic textile practices support wellbeing and social connection through intertwined material, digital, and interpersonal pathways [16]. Experimental evidence showed that even brief group-singing activities can accelerate social bonding among participants who were previously unfamiliar with one another [17]. Qualitative research on group drumming identified communication, mutual support, and collective identity as mechanisms through which participatory music may contribute to recovery and mental wellbeing [18].

A national survey later found that adults often see arts engagement, particularly live music, theatre, and cinema, as contributing to social connectedness [19]. Textile-craft research found that creative activity can generate eudaimonic wellbeing through meaning, competence, identity, and social relationships [20]. A meta-review similarly concluded that augmented reality can improve learning but can also create distraction and cognitive burden when technological novelty does not align with pedagogy [21].

Research on augmented-reality applications emphasized that their educational value depends on the relationship among prototype design, learning objectives, user interaction, and evaluation [22]. Experimental evidence also suggested that music may temporarily function as a form of social connection when direct interpersonal interaction is limited [23]. An exhibition-based field experiment demonstrated that carefully integrated digital overlays can improve knowledge acquisition in informal learning environments [24].

Research on music and social bonding explained how embodied coordination, shared attention, self-other merging, and neurohormonal processes may enable collective music-making to strengthen affiliation [25]. Sustained museum programs have also been shown to create opportunities for communication and inclusion among socially isolated adults [26]. Research at heritage sites found that augmented reality creates public value only when visitor needs, institutional objectives, and cultural interpretation are aligned [27].

Further research on wearable augmented reality in art galleries showed that evaluators should assess technological applications by visitor learning and interpretive outcomes rather than technological novelty alone [28]. Repeated engagement with museums, galleries, and exhibitions has been associated with lower loneliness in both cross-sectional and longitudinal analyses [29]. National evidence also documented substantial social inequalities in the forms and frequency of arts engagement and showed that these differences have implications for mental and social wellbeing [30].

A national fixed-effects panel analysis found that arts engagement remained associated with mental-health functioning and life satisfaction after controlling for stable individual characteristics [31]. Longitudinal evidence similarly indicated that changes in engagement with arts, culture, and sport were associated with improvements in selected dimensions of subjective wellbeing [32]. Taken together, these studies show that arts learning, digital access, creative production, and social participation are related but distinct processes whose benefits depend on pedagogy, institutional support, opportunities for active involvement, and equitable access.

The empirical literature points to four recurring relationships. First, structured arts education is associated with interpretive skill, confidence, and continued participation. Second, digital media can extend access and support multimedia learning, but their benefits depend on access, literacy, and design. Third, active creation and performance often have stronger relational components than passive exposure because

they involve practice, coordination, and public expression. Fourth, arts participation can support social connectedness, volunteering, cultural support, and community involvement. The studies summarized in Table 1 provide the evidence base for these relationships.

Table 1. Comparative evidence base of the reviewed studies.

No	Author(s) and year	Design / focus	Contribution to the framework
1	Akçayır and Akçayır (2017)	Systematic review of educational AR	Synthesizes motivation, visualization, usability, and cognitive-load findings.
2	Bekele et al. (2018)	Cultural-heritage technology review	Maps digital reconstruction, preservation, and interpretation applications.
3	Bennington et al. (2016)	Museum art-therapy program	Connects visual-art engagement with social connectedness and wellbeing.
4	Billinghurst, Clark, and Lee (2015)	Human-computer interaction review	Defines usability and interaction conditions for augmented environments.
5	Bowen, Greene, and Kisida (2014)	Randomized visual-art field experiment	Arts exposure strengthened critical interpretation; supports arts learning as capability development.
6	Bullack et al. (2018)	Choral-singing psychobiology study	Links artistic participation with affect, connectedness, and stress.
7	Dadswell et al. (2017)	Conceptual review of participatory arts	Links arts activity with belonging, self-worth, and reduced loneliness.
8	Daykin et al. (2021)	Qualitative systematic review	Explains social-capital mechanisms in participatory arts.
9	Fancourt and Steptoe (2018)	Longitudinal population analysis	Associates cultural engagement with cognitive outcomes.
10	Fancourt and Tymoszuk (2019)	Longitudinal depression study	Finds a graded association between cultural engagement and depression risk.
11	Garzón and Acevedo (2019)	Meta-analysis of AR learning gains	Reports positive average effects with substantial contextual variation.
12	He, Wu, and Li (2018)	Museum augmented-reality study	Relates AR design to experience and behavioral response.
13	Ibáñez and Delgado-Kloos (2018)	Systematic review of AR learning	Emphasizes instructional strategy and outcome measurement.
14	Leue, Jung, and Tom Dieck (2015)	Wearable art-gallery interpretation	Links digital interpretation to generic learning outcomes.
15	Mihelj, Leguina, and Downey (2019)	Digital cultural-participation analysis	Shows that digital cultural access remains socially unequal.
16	Nevay et al. (2019)	Mixed-method study of traditional and e-textiles	Connects material and digital making with wellbeing and relationships.

No	Author(s) and year	Design / focus	Contribution to the framework
17	Pearce, Launay, and Dunbar (2015)	Experimental group-singing study	Shows accelerated social bonding through shared artistic activity.
18	Perkins et al. (2016)	Qualitative group-drumming research	Identifies collective music-making as a pathway to recovery and support.
19	Perkins et al. (2021)	National arts and connectedness survey	Finds broad perceived links between arts engagement and social connection.
20	Pöllänen and Weissmann-Hanski (2020)	Qualitative textile-craft study	Identifies meaning, skill, identity, and connection in creative practice.
21	Radu (2014)	Meta-review of augmented reality in education	Identifies learning benefits alongside cognitive and attention risks.
22	Santos et al. (2014)	Review of augmented-reality learning designs	Connects technology design with learning objectives and evaluation.
23	Schäfer, Saarikallio, and Eerola (2020)	Experimental music-listening study	Shows music can function as a temporary social surrogate.
24	Sommerauer and Müller (2014)	Field experiment in an exhibition	Shows that integrated digital overlays can improve informal learning.
25	Tarr, Launay, and Dunbar (2014)	Conceptual and empirical synthesis of music bonding	Explains embodied and neurohormonal pathways of social affiliation.
26	Todd et al. (2017)	Museum programs for isolated adults	Explains how sustained cultural activity can reduce isolation.
27	Tom Dieck and Jung (2017)	Stakeholder study at heritage sites	Shows that institutional and visitor conditions shape technological value.
28	Tom Dieck, Jung, and Tom Dieck (2018)	Wearable AR in art galleries	Evaluates technology through visitor learning rather than novelty.
29	Tymoszuk et al. (2020)	Cross-sectional and longitudinal loneliness study	Associates receptive arts engagement with reduced loneliness.
30	Tymoszuk et al. (2021)	National HEartS survey	Documents social inequalities and wellbeing implications of arts engagement.
31	Wang, Mak, and Fancourt (2020)	National fixed-effects panel analysis	Associates arts engagement with mental functioning and life satisfaction.
32	Wheatley and Bickerton (2019)	Longitudinal wellbeing analysis	Links changes in arts engagement with selected wellbeing domains.

III.RESEARCH AIM, GAP, HYPOTHESES AND CONTRIBUTION

1. RESEARCH AIM AND QUESTIONS

The research aims to examine how arts education, digital participation, artistic creation, and community engagement relate within a multidisciplinary framework for visual and performing arts. The study asks whether school-based and informal arts learning are associated with digital arts engagement and active artistic creation; whether digital engagement and creative practice are associated with community participation and arts-related civic support; and whether these relationships remain evident after accounting for demographic and socioeconomic differences. These questions are addressed through separate module-pair analyses because the survey randomly assigned respondents to one technology or creation module and one community or education module.

2. RESEARCH GAP

Three gaps remain. First, the literature rarely connects arts education, digital participation, active creation, and community engagement in a single population model. Second, technology studies frequently focus on a particular device or intervention, whereas population studies often measure cultural participation without distinguishing digital viewing, digital sharing, creative production, and arts learning. Third, researchers often examine community outcomes in small programs or targeted groups, leaving uncertainty about whether the proposed relationships hold across a national adult population. This research addresses these gaps by aligning four survey modules into an integrated pathway and estimating associations with design-correct uncertainty.

3. CONCEPTUAL FRAMEWORK AND HYPOTHESES DEVELOPMENT

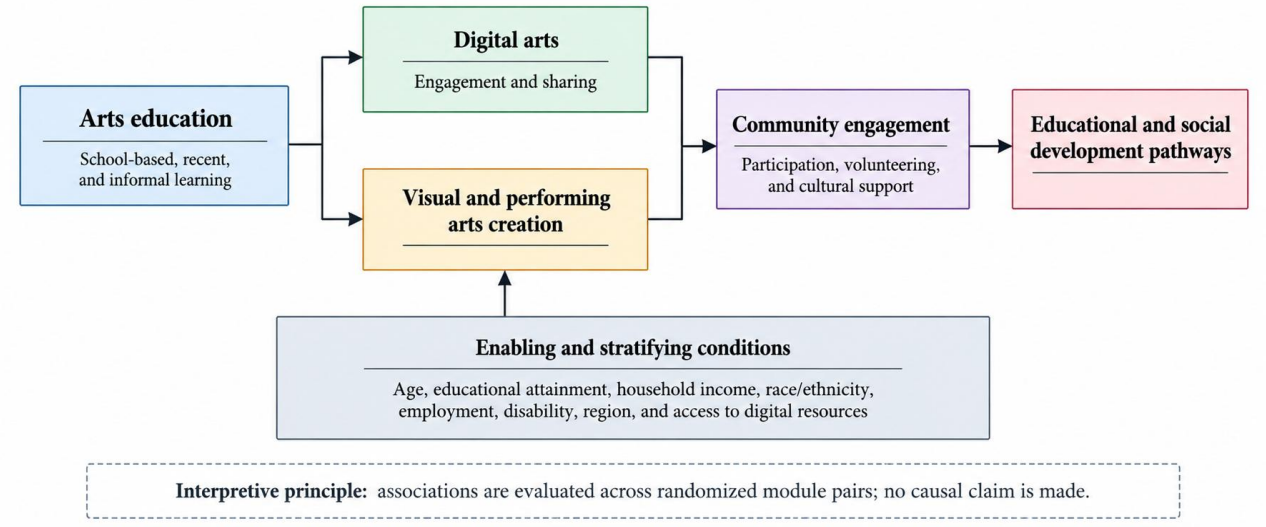


FIGURE 1. Multidisciplinary framework linking arts education, digital participation, creation, and community engagement.

The framework treats arts learning as an enabling foundation, digital and creative participation as intermediate practices, and community engagement as a wider social outcome conditioned by unequal resources and opportunities.

The framework generates six testable expectations. School-based arts education and informal arts learning are expected to be positively associated with digital arts engagement and digital sharing. The same learning experiences are expected to be associated with active artistic creation, specifically digital creation. Digital arts engagement and online sharing are expected to be associated with community participation. Artistic creation

and sharing of creative work are likewise expected to be associated with community participation. We evaluate these expectations as adjusted associations, not causal effects, because the survey records current and retrospective characteristics at one point in time.

4. STUDY CONTRIBUTION

The study's originality lies in integrating arts education, digital cultural participation, artistic production, and community engagement within a single empirical architecture. Rather than defining technology as a single device or treating social development as a distant national indicator, the framework follows observable individual pathways: learning the arts, engaging with arts through digital media, producing or performing art, sharing creative work, and participating in community or cultural life. Using official replicate weights strengthens statistical inference and makes the findings more suitable for policy and institutional interpretation.

IV. PROPOSED METHOD

The proposed method is a split-module pathway analysis designed for a complex national survey. It converts the broad relationship among art, technology, education, and development into four empirically observable transitions. The A-D sample evaluates whether arts education is associated with digital engagement and sharing. The B-D sample evaluates whether arts education is associated with artistic and digital creation. The A-C sample evaluates whether digital participation is associated with community engagement. The B-C sample evaluates whether artistic creation and sharing are associated with community engagement. This architecture respects the survey's randomized module assignment and avoids imputing constructs that were never observed together.

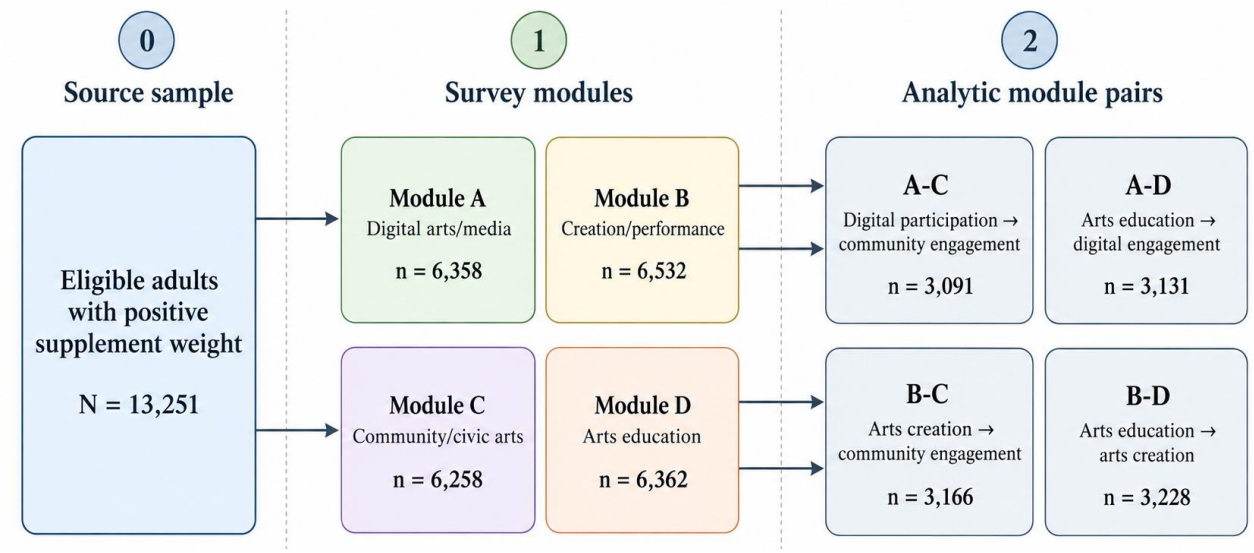


FIGURE 2. Randomized survey modules and valid analytic pairings.

The four pairings preserve the survey design. Modules A and B were mutually exclusive, as were Modules C and D, so relationships across those mutually exclusive pairs were not estimated.

Table 2. Proposed module-pair pathway tests.

Module pair	Pathway	Outcomes	Principal predictors
A-D	Arts education -> digital participation	Digital arts/media engagement; digital sharing	School-based arts education; informal learning
B-D	Arts education -> creative practice	Any creation/performance; digital creation	School-based arts education; informal learning
A-C	Digital participation -> community	Community participation; arts civic support	Digital engagement; digital sharing
B-C	Creative practice -> community	Community participation; arts civic support	Any creation; digital creation; internet sharing

V. METHODOLOGY

1. *RESEARCH DESIGN*

The study adopts a quantitative, cross-sectional, secondary-analysis design. The unit of analysis is the individual adult respondent. The study uses nationally representative survey weights for prevalence estimation and 160 replicate weights to estimate sampling variance for both descriptive statistics and regression coefficients. The design is explanatory in structure but associational in interpretation.

2. *DATA SOURCE, PARTICIPANTS, AND SURVEY STRUCTURE*

The evidence comes from the 2022 Survey of Public Participation in the Arts, administered as a supplement to the Current Population Survey by the U.S. Census Bureau for the National Endowment for the Arts. The person-level public-use source contains 127,084 records. The arts supplement selected one adult aged 18 or older from about half of sampled households and assigned one core section and two modules. The technology and creation modules were randomized alternatives, as were the community and education modules [33], [34].

The accompanying replicate-weight source contains 40,718 person records and 160 replicate weights. Linking the two sources on the survey household and person keys produced 40,718 matched records; 13,251 had a positive supplement weight and were eligible for weighted analysis. Module-specific valid sample sizes ranged from 6,258 to 6,532, while paired regression samples ranged from 3,091 to 3,228. The public-use source and technical documentation are made available by the Census Bureau [33], [34].

Table 3. Analytic sample and module structure.

Sample component	Unweighted n	Analytic role
Public-use person records	127,084	All persons represented in the released person-level source
Matched replicate-weight records	40,718	Records available for design-based variance estimation
Positive supplement-weight adults	13,251	Eligible weighted analytic pool
Module A: digital arts/media	6,358	Electronic participation, device use, and digital sharing
Module B: creation/performance	6,532	Visual, performing, written, and digital creation

Sample component	Unweighted n	Analytic role
Module C: community/civic arts	6,258	Volunteering, local events, subscriptions, donations, and purchases
Module D: arts education	6,362	Lifetime, school-based, recent, and informal arts learning
A-C paired sample	3,091	Digital participation and community models
A-D paired sample	3,131	Arts education and digital participation models
B-C paired sample	3,166	Creation and community models
B-D paired sample	3,228	Arts education and creation models

3. *SAMPLE SELECTION AND INCLUSION CRITERIA*

We retained records that matched the replicate-weight source and had a positive supplement weight. A respondent was classified as belonging to a module when at least one primary module item contained a substantive yes or no response. Models were restricted to respondents observed in both required modules. Nonresponse codes, refusals, don't-know responses, and not-in-universe codes were treated as missing rather than as substantive absence. Conditional follow-up items were coded as zero only when the parent module established that the respondent was valid and the follow-up represented absence of the specified behavior.

4. *VARIABLES, MEASURES, AND CODING FRAMEWORK*

Table 4. Operational definitions of principal variables.

Construct	Role	Operational definition	Source
Digital arts/media engagement	Outcome / predictor	Any device-based engagement with music, theatre, dance, visual art, books/writers, documentaries, or visual-art viewing	Module A
Digital sharing about arts	Outcome / predictor	Any online posting or sharing about music/dance, movies, visual art, or books	Module A
Device use in performance	Descriptive outcome	Used a digital device as part of a performance	Module A
Any artistic creation/performance	Outcome / predictor	Any craft, visual-art, film, photography, writing, music, dance, acting, software/game, or digital-art activity	Module B
Digital artistic creation	Outcome / predictor	Created art using an electronic device	Module B
Internet sharing of creative work	Predictor	Shared personally created artistic work through the internet	Module B
Community participation	Outcome	Any volunteer/charity work or participation in community events	Module C
Arts-related civic support	Robustness outcome	Any arts volunteering, arts subscription, donation, or art purchase	Module C

Construct	Role	Operational definition	Source
Lifetime arts training	Robustness predictor	Any lifetime lesson or training in music, photography, visual arts, acting, dance, writing, art history, or creative coding/digital art	Module D
School-based arts education	Primary predictor	Any specified arts learning undertaken in school	Module D
Recent arts class	Robustness predictor	Any specified class or lesson during the recent reference period	Module D
Informal arts learning	Primary predictor	Any self-directed or informal learning in the specified arts domains	Module D
Covariates	Controls	Age group, sex, educational attainment, race/ethnicity, household income, employment, disability, and region	CPS core

5. *ANALYTICAL PROCEDURE*

Analysis proceeded in five stages. First, we linked the public-use and replicate-weight records using the questionnaire and person-occurrence identifiers. Second, we derived module eligibility and binary constructs from documented response codes. Third, we calculated national prevalence estimates using the supplement weight. Fourth, weighted logistic regressions were fitted separately within the four valid module-pair samples. Fifth, we re-estimated each coefficient using all 160 replicate weights and used the replicate dispersion to calculate design-based standard errors, confidence intervals, and significance tests.

For a binary outcome y, the design-weighted prevalence estimate was calculated as:

$$\hat{p} = (\Sigma_i w_i y_i) / (\Sigma_i w_i) \quad (1)$$

The replicate-weight variance followed the Census Bureau generalized variance procedure:

$$Var(\theta) = (4 / 160) \Sigma_{r=1}^{160} (\theta_r - \theta)^2 \quad (2)$$

Adjusted associations were estimated with weighted logistic regression:

$$log[p_i / (1 - p_i)] = \beta_0 + \beta_1 X_{1i} + \ldots + \beta_k X_{ki} \quad (3)$$

The exponentiated coefficient exp(β) is reported as an adjusted odds ratio. All models included age, sex, educational attainment, race and ethnicity, household income, employment, disability, and region. Because multiplying all weights by a constant does not change proportions or logistic coefficients, module scaling factors do not affect the reported ratios; the official supplement and replicate weights were nevertheless used consistently in all calculations.

6. *VALIDITY, RELIABILITY, AND ETHICAL CONSIDERATIONS*

We strengthened construct validity by aligning each composite with multiple questionnaire items representing the same behavioral domain. We intentionally separated digital engagement and creation because viewing or discussing art through a device is not equivalent to producing art. We also distinguished community participation from arts-specific civic support. Sensitivity analyses replaced school arts education with lifetime or recent learning and replaced general community participation with arts-specific civic support.

In this context, reliability concerns coding reproducibility and survey-design inference rather than the internal consistency of a psychometric scale. We generated all composites using transparent, deterministic rules, and we reproduced all estimates with the same 160 replicate weights. The survey followed federal statistical procedures, and the released files contain de-identified public-use records. The secondary analysis did not contact participants or access direct identifiers; however, future users should still follow institutional requirements for public-use data.

VI. RESULTS / FINDINGS

1. *WEIGHTED PARTICIPATION PROFILE*

Digital contact with arts and culture was widespread: 74.5% of adults in Module A engaged with at least one specified arts or cultural form through a digital device. 51.8% of adults in Module B reported active artistic creation or performance. Arts learning was also common, with 55.0% reporting lifetime training and 48.4% reporting school-based arts education. Community participation was less prevalent but still substantial at 29.3%, while 20.9% reported at least one form of arts-related civic support. More specialized digital production behaviors were less common: 4.5% reported digital artistic creation, 7.0% used a device in a performance, and 10.8% shared creative work online.

Table 5. National design-weighted prevalence estimates.

Indicator	n	Weighted %	95% CI
Digital arts/media engagement	6,358	74.5	73.0-76.0
Digital sharing about arts	6,358	19.4	18.3-20.6
Use of a device in performance	6,358	7.0	6.2-7.9
Any artistic creation or performance	6,532	51.8	50.1-53.6
Digital artistic creation	6,532	4.5	3.8-5.2
Internet sharing of creative work	6,532	10.8	9.8-11.7
Community participation	6,258	29.3	27.8-30.7
Arts-related civic support	6,258	20.9	19.6-22.1
Lifetime arts training	6,362	55.0	53.3-56.7
School-based arts education	6,362	48.4	46.5-50.2
Recent arts class or lesson	6,362	11.8	10.7-13.0
Informal/self-directed arts learning	6,362	25.4	23.9-27.0

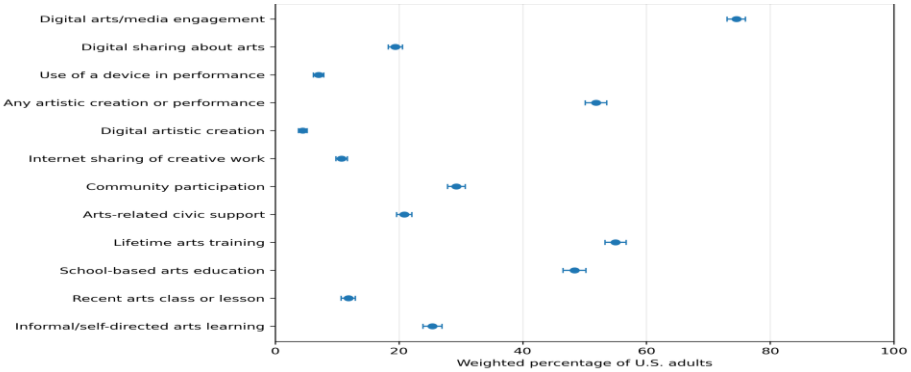


FIGURE 3. Weighted prevalence of arts education, digital participation, creation, and community engagement.

The figure shows point estimates with replicate-weighted 95% confidence intervals. Digital engagement was common, whereas specialized digital creation and device-based performance were comparatively rare.

2. *ARTS EDUCATION AND DIGITAL PARTICIPATION*

In the A-D paired sample, both school-based arts education and informal arts learning were strongly associated with digital participation after adjustment. Adults reporting school-based arts education had 3.57 times the odds of digital arts/media engagement compared with otherwise similar adults without such education. Informal arts learning had adjusted odds of 4.18. For digital sharing about arts, the corresponding adjusted odds ratios were 2.61 for school-based education and 2.43 for informal learning. These results support the proposition that formal and self-directed learning are connected to later technological engagement with art.

3. *ARTS EDUCATION AND CREATIVE PRACTICE*

The B-D paired sample produced a similar but even stronger pattern for active creation. School-based arts education was associated with 3.41 times the odds of any artistic creation or performance, while informal learning was associated with 6.09 times the odds. For digital artistic creation specifically, the adjusted odds ratios were 4.68 and 5.91, respectively. The wider confidence interval for school-based education in the digital-creation model reflects the comparatively low prevalence of that outcome.

4. *DIGITAL PARTICIPATION, CREATION, AND COMMUNITY ENGAGEMENT*

Within the A-C sample, digital arts/media engagement was associated with 3.16 times the odds of community participation, and digital sharing about arts was associated with 2.38 times the odds. In the B-C sample, any artistic creation or performance was associated with 3.44 times the odds of community participation. Internet sharing of creative work remained positively associated with community participation (OR=1.67), whereas digital creation alone was not statistically distinguishable from no association after we included active creation and internet sharing in the same model. This distinction suggests that the relational circulation of creative work may be more directly connected to community participation than the use of a digital production tool by itself.

Table 6. Principal replicate-weighted logistic regression results.

Model	Outcome	Predictor	n	Adjusted OR	95% CI	p
M1	Digital engagement (A–D)	School-based arts education	3,131	3.57	2.59-4.94	<0.001
M1	Digital engagement (A–D)	Informal arts learning	3,131	4.18	2.85-6.12	<0.001
M2	Digital arts sharing (A–D)	School-based arts education	3,131	2.61	1.83-3.70	<0.001
M2	Digital arts sharing (A–D)	Informal arts learning	3,131	2.43	1.76-3.35	<0.001
M3	Artistic creation (B–D)	School-based arts education	3,228	3.41	2.69-4.31	<0.001
M3	Artistic creation (B–D)	Informal arts learning	3,228	6.09	4.52-8.19	<0.001
M4	Digital creation (B–D)	School-based arts education	3,228	4.68	1.83-11.96	0.001
M4	Digital creation (B–D)	Informal arts learning	3,228	5.91	3.49-10.03	<0.001
M5	Community participation (A–C)	Digital arts/media engagement	3,091	3.16	2.20-4.54	<0.001
M5	Community participation (A–C)	Digital sharing about arts	3,091	2.38	1.87-3.04	<0.001

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Model	Outcome	Predictor	n	Adjusted OR	95% CI	p
M6	Community participation (B–C)	Any artistic creation	3,166	3.44	2.62-4.50	<0.001
M6	Community participation (B–C)	Digital artistic creation	3,166	1.44	0.80-2.61	0.227
M6	Community participation (B–C)	Internet sharing of creative work	3,166	1.67	1.08-2.56	0.020

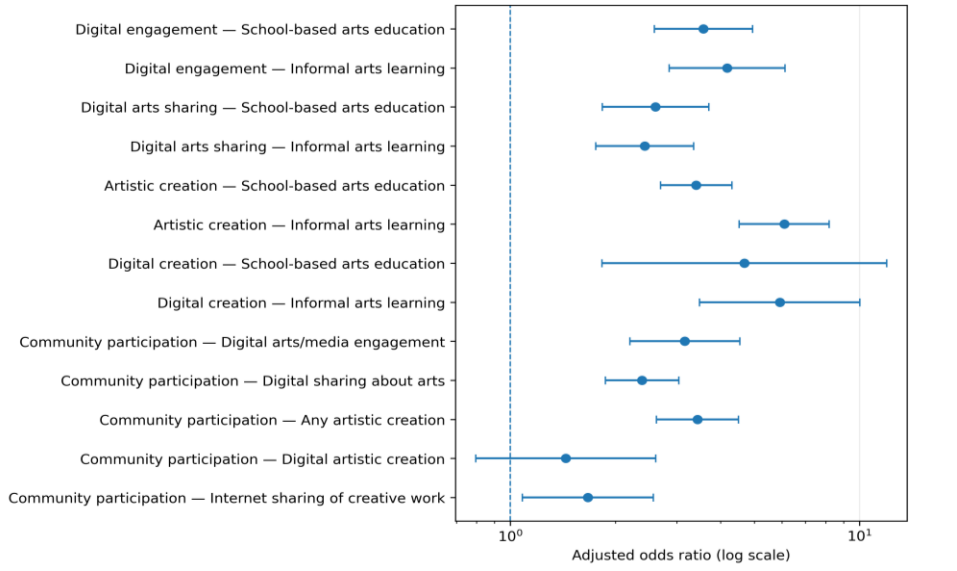


FIGURE 4. Adjusted associations across the multidisciplinary pathway.

Odds ratios are adjusted for age, sex, education, race/ethnicity, household income, employment, disability, and region. The vertical reference line marks no association.

5. EDUCATIONAL GRADIENTS

Participation was socially graded. Digital engagement rose from 59.4% among adults with less than a high school education to 83.6% among those with a graduate education. Artistic creation increased from 37.4% to 64.1% across the same groups. Community participation rose from 12.6% to 49.0%, while school-based arts education increased from 15.0% to 70.9%. These gradients indicate that the framework operates within unequal distributions of educational and socioeconomic opportunity.

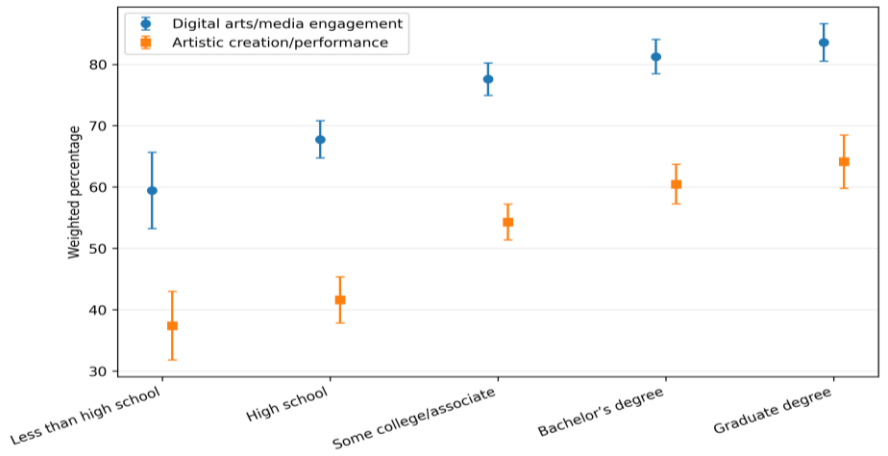


FIGURE 5. Digital arts engagement and artistic creation by educational attainment.

The weighted gradients show that access to digital and creative participation is not evenly distributed. Educational attainment should therefore be treated as both a control and a policy-relevant stratifying condition.

6. *ROBUSTNESS ANALYSES*

Table 7. Robustness and alternative-outcome models.

Model	Outcome	Predictor	n	Adjusted OR	95% CI	p
R1	Digital engagement—lifetime training	Lifetime arts training	3,131	4.77	3.60-6.30	<0.001
R2	Artistic creation—recent lessons	Recent arts class	3,228	7.94	4.50-13.99	<0.001
R3	Arts civic support (A–C)	Digital arts/media engagement	3,091	2.93	1.94-4.44	<0.001
R3	Arts civic support (A–C)	Digital sharing about arts	3,091	3.43	2.55-4.63	<0.001
R4	Arts civic support (B–C)	Any artistic creation	3,166	3.65	2.76-4.81	<0.001
R4	Arts civic support (B–C)	Digital artistic creation	3,166	1.74	0.96-3.15	0.066
R4	Arts civic support (B–C)	Internet sharing of creative work	3,166	2.09	1.41-3.09	<0.001

Alternative specifications supported the main interpretation. Lifetime arts training was associated with digital engagement at an adjusted odds ratio of 4.77, and recent arts classes were associated with artistic creation at 7.94. Digital engagement, digital sharing, and active creation remained strongly associated when the outcome was restricted to arts-related civic support. Digital creation again produced a less precise estimate, while internet sharing remained positively associated. The consistency across general and arts-specific community outcomes reduces the likelihood that the findings depend on a single coding choice.

VII. DISCUSSION

The findings support the central proposition that art, technology, education, and community development are connected through a sequence of participatory practices. Arts learning was not merely associated with conventional cultural attendance; it was strongly related to digital engagement, sharing, artistic production, and digital creation. These relationships remained substantial after adjustment for demographic and socioeconomic characteristics. The results therefore support viewing arts education as a long-term participation infrastructure rather than a narrowly curricular experience.

The association between school-based arts education and later digital engagement is particularly important. Digital culture is sometimes described as a replacement for institutional arts learning because online platforms make content widely available. The evidence suggests a different interpretation: formal learning and digital participation complement each other. Individuals with arts education may have the vocabulary, confidence, technical familiarity, and sustained interest needed to actively navigate cultural content. Informal learning also showed strong associations, indicating that pathways outside formal schooling remain important for adults who continue to develop creative skills.

Active artistic creation displayed an even stronger relationship with informal learning. This finding is consistent with the practical nature of visual and performing arts, where continued competence often depends on rehearsal, experimentation, peer exchange, tutorials, workshops, and self-directed practice. The result does not diminish formal education; rather, it suggests that sustained creative participation may depend on an ecology in which schools establish foundations and informal settings provide continuity across adulthood.

The community models extend the framework beyond individual learning. Digital engagement was associated with community participation, while digital sharing showed an additional relationship after adjustment. This pattern suggests that online cultural activity may connect people to broader networks, events, interests, and organizations. Yet this relationship should not be interpreted as proof that digital exposure drives civic behavior. People who are already socially active may also seek more cultural content and use digital media to coordinate existing interests. Longitudinal and experimental studies are needed to distinguish these possibilities.

Artistic creation was one of the strongest predictors of community participation. Creative practice may generate community ties through classes, rehearsals, exhibitions, performances, workshops, clubs, and informal networks. Visual and performing arts often require spaces, audiences, collaborators, teachers, or communities of practice. Even solitary forms such as photography, writing, textile work, or digital design can become relational when people share, discuss, exhibit, or sell their work. This helps explain why internet sharing remained associated with community participation beyond creation itself.

Digital creation alone did not show an independent association with community participation in the fully adjusted B-C model. This is a theoretically informative non-significant result. Using a device to create art is not necessarily social; it can remain private and disconnected from organizations or public interaction. By contrast, sharing creative work introduces circulation, feedback, audience, and network contact. Development strategies should therefore avoid equating access to production software with community engagement. Platforms, institutional partnerships, public presentations, and collaborative opportunities may be needed to turn digital production into social participation.

The educational gradients reveal an important equity problem. Adults with higher formal education reported substantially more school arts education, digital engagement, artistic creation, and community participation. These differences are not fully explained by the main pathway and likely reflect cumulative advantage: better-resourced schools, household cultural exposure, access to devices, discretionary time, transportation, local institutions, and confidence in cultural settings. A multidisciplinary framework must therefore treat inequality as a structural condition rather than as an individual preference.

The results also clarify what social development means in this study. Development is not represented by a broad national index imposed on individual survey records. It is operationalized through participation in community events, volunteering, cultural subscriptions, donations, and purchases. These behaviors do not capture every dimension of social cohesion or development, but they offer observable pathways for arts engagement to enter public and community life. This approach is more empirically coherent than merging person-level participation records with country-level indicators.

The survey's split-module architecture is both a strength and a limitation. Random assignment reduces systematic differences between module groups and supports valid paired analyses. At the same time, no respondent completed both digital and creation modules or both community and education modules. A single sequential mediation model therefore cannot be estimated directly. The framework is supported by linked associations across randomized pairs, not by observing the entire pathway within the same individuals. Future longitudinal surveys should administer a shorter common set of measures across all respondents to test mediation and temporal ordering.

Overall, the evidence supports a balanced interpretation. Arts education is associated with later digital and creative participation; these participatory forms are associated with community involvement; and inequality conditions access at every stage. Technology expands the channels through which people can encounter, produce, and circulate art, but it does not replace pedagogy, institutions, or social relationships. The strongest development pathway appears to combine learning, creation, sharing, and opportunities for public participation.

The study represents adults in the United States during a particular survey period. Results may differ for children, adolescents, specific cultural communities, other countries, or later periods of technological change.

Future research should combine longitudinal arts-education histories with repeated measures of online engagement, creative production, social networks, and civic participation. Quasi-experimental studies of school provision, community programs, and digital-access interventions would improve causal inference. Qualitative research should also examine how individuals move between viewing, learning, making, sharing, and community roles.

VIII. PRACTICAL AND POLICY IMPLICATIONS

Table 8. Institutional and policy implications of the framework.

Stakeholder	Recommended action
Schools and universities	Protect sustained access to visual and performing arts; connect foundational learning with digital production, interpretation, and public presentation.
Museums and cultural institutions	Develop hybrid programs that combine online access with workshops, discussion, creation, volunteering, and community events.
Community organisations	Use arts programs as participation infrastructures, with routes from learning to collaborative making, exhibition, performance, and civic involvement.
Digital platforms	Support discovery, accessible creation tools, attribution, safe sharing, feedback, and links to local cultural opportunities rather than content consumption alone.
Public policy	Address educational and digital inequalities together through devices, connectivity, transport, local venues, educator development, and affordable participation.
Evaluation practice	Measure learning, creation, sharing, and community outcomes separately; report design-adjusted uncertainty and avoid causal claims from cross-sectional evidence.

For education policy, the results support treating arts provision as part of digital and civic capability. Arts learning can include photography, film, music technology, creative coding, digital art, online curation, and multimedia performance without abandoning material, embodied, or face-to-face practice. The objective is not technological substitution but expanded creative agency.

For cultural institutions, online reach should be linked to pathways for active participation. Streaming, virtual exhibitions, and social-media communication may increase contact, but stronger community value

may emerge when audiences can learn, create, discuss, volunteer, attend events, or share work. Institutions should therefore design hybrid participation ladders rather than isolated digital products.

For community development, investment should prioritize continuity. Short projects can generate interest, but pathways from introductory activity to sustained learning, collaborative creation, public presentation, and leadership are more likely to build durable relationships. Adults with lower educational attainment, limited income, disability, or limited access to cultural infrastructure need particular attention.

IX.CONCLUSION

This study transformed a broad multidisciplinary proposition about art, technology, education, and development into a design-weighted national analysis. The evidence indicates that school-based and informal arts learning are strongly associated with later digital arts engagement and active visual or performing arts creation. Digital engagement and artistic creation, in turn, are associated with community participation, while the circulation of creative work appears more socially relevant than digital production alone. These relationships persist after adjustment for major demographic and socioeconomic characteristics, but substantial educational gradients show that participation opportunities remain unequal. The findings do not establish causal effects, and the randomized split-module design prevents direct observation of the full pathway in one respondent. Nevertheless, consistent results across four valid module pairs and alternative outcomes provide an empirically grounded basis for the proposed framework. Arts education should therefore be understood not only as curricular enrichment but as a foundation for digital cultural capability, creative agency, and participation in community life. Technology is most developmentally valuable when it extends learning, enables creation, supports sharing, and connects individuals with institutions and one another.

Author Contributions

The author conducted the conceptualization, methodology, data analysis, investigation, writing, review, editing, and final approval of the manuscript.

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Data Availability

The dataset will be available from the author upon reasonable request.

Conflicts of Interest

The author declares no conflict of interest.

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APPENDIX A. SURVEY VARIABLE MAP

Construct	Variables	Coding rule
Digital engagement	PEMAQ1A-PEMAQ1J; PEMAQ3A	Any substantive yes across specified digital arts/media forms
Digital sharing	PEMAQ5A-PEMAQ5D	Any online posting/sharing about arts and cultural content
Device performance	PEMAQ4A	Yes response
Artistic creation/performance	PEMBQ1A-PEMBQ1N	Any substantive yes across creation and performance activities
Digital artistic creation	PEMBQ1N	Yes response
Internet sharing of creative work	PEMBQ4A	Yes response; conditional nonparticipants coded as absence
Community participation	PEMCQ3A; PEMCQ7	Volunteer/charity work or participation in community events
Arts civic support	PEMCQ3B; PEMCQ4-PEMCQ6	Arts volunteering, subscription, donation, or purchase
Lifetime arts training	PEMDQ1A-PEMDQ1H	Any lifetime lesson or training
School arts education	PEMDQ2A-PEMDQ2H	Any specified learning undertaken in school
Recent arts class	PEMDQ3A-PEMDQ3H	Any recent lesson or class
Informal arts learning	PEMDQ4A-PEMDQ4H	Any self-directed or informal learning

APPENDIX B. MODEL SPECIFICATIONS

Model	Pair	Outcome	Principal predictors
M1	A-D	Digital engagement	School arts education; informal learning
M2	A-D	Digital sharing	School arts education; informal learning
M3	B-D	Any artistic creation	School arts education; informal learning
M4	B-D	Digital creation	School arts education; informal learning
M5	A-C	Community participation	Digital engagement; digital sharing
M6	B-C	Community participation	Any creation; digital creation; internet sharing
R1	A-D	Digital engagement	Lifetime arts training
R2	B-D	Any artistic creation	Recent arts class
R3	A-C	Arts civic support	Digital engagement; digital sharing
R4	B-C	Arts civic support	Any creation; digital creation; internet sharing

We adjusted every model for age group, sex, educational attainment, race and ethnicity, household income, employment status, disability status, and Census region. Design-based standard errors were calculated from all 160 person-level replicate weights using the official 4/160 variance factor.

Appendix C. Reproducibility and data-quality checks

Check	Implementation
Record linkage	One-to-one merge on questionnaire number and person occurrence number; the first replicate weight reproduced the supplement weight.
Eligibility	Positive supplement weight required; module membership confirmed from substantive response codes.
Nonresponse	Refusal, no-answer, do-not-know, and not-in-universe codes were excluded from substantive yes/no calculation.
Module integrity	No A-B or C-D model was estimated because these modules were mutually exclusive.
Variance estimation	All prevalence and coefficient estimates recalculated under 160 replicate weights.
Sensitivity analysis	Alternative learning predictors and arts-specific civic outcomes evaluated.
Interpretive constraint	Results reported as adjusted associations, not causal impacts or longitudinal change.