

Multidisciplinary Learning Through Student Chosen Interests

Evidence for teaching mathematics science and writing together

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Abstract

Tiny Orange proposes that learners select or generate interest words, sort them under mathematics, science, or writing, and use a chosen word as the entry point to a defined academic target. This narrative review examines evidence for integrated STEM instruction, personalized contexts, learner choice, writing to learn, and arts integration. A meta-analysis of integrated STEM studies reports higher average achievement under integration, and an algebra experiment found that personalized problems particularly helped students who were struggling. Writing about subject matter also improves learning across mathematics and science. The evidence supports a careful design: teach the target concept explicitly inside an authentic interest context, link it to the other disciplines, and assess it again without the original context. A worked ballet example shows how a student can learn choreography while building and transferring a linear model. Tiny Orange's complete word-sorting and Recursive Skip Logic pathway remains a design proposal that requires its own evaluation.

Keywords multidisciplinary learning; integrated STEM; algebra; writing to learn; student interest; transfer; arts integration

Introduction

Mathematics describes relationships, science tests explanations of the world, and writing makes reasoning visible to another person. Students frequently use all three in the same real task, yet school schedules and assessments often present them as separate courses. Teaching them together has a defensible purpose when each discipline contributes genuine work to a shared question. The goal is disciplinary competence that survives a change of context, not a pleasant activity that merely contains numbers.

Tiny Orange begins with a learner's own point of entry. A student or parent can choose from a bank of words, make a new list, or request an automatically generated list. The learner then sorts words into mathematics, science, or writing; a word may sit in more than one category. Selecting "ballet" under mathematics tells the teacher where to begin. It does not limit ballet to mathematics, or permit algebra to disappear into a dance activity. The instructor identifies an algebra target, teaches through authentic ballet decisions, and checks whether the student can later solve a different algebra problem independently.

This review asks two connected questions. What does research support about integrating content and personal interests? What must Tiny Orange do to ensure that a learner who has repeatedly failed algebra can actually learn algebra? The strongest answer is a design and measurement argument. Evidence supports several components, but no cited study tests the entire Tiny Orange system as a package.

Review scope and evidence

This is a targeted narrative review, not an exhaustive systematic review. It draws on peer-reviewed experiments and research syntheses, a National Academies review, and an Institute of Education Sciences practice guide available as of September 2026. Studies differ in grade level, subject, length, and outcome measures. The ballet sequence below is an instructional illustration; Bijou is a hypothetical learner, and no improvement is reported as an observed Tiny Orange result.

Integrated teaching can improve learning when the connections are explicit

A recent meta-analysis combined 79 effect sizes from 40 studies involving 15,577 learners. Students in integrated STEM conditions outperformed comparison students on academic achievement measures on average, with a reported Hedges' g of 0.661 (95% CI [0.548, 0.774]). Results varied by the form of integration and the subject tested; the authors reported smaller effects for mathematics achievement than for some other outcomes (Zhou et al., 2025). This is evidence of promise across heterogeneous programs, not an estimate of what Tiny Orange or a ballet unit will produce.

The National Academies' review makes the design requirement sharper. It found promising conceptual learning but less consistent mathematics outcomes than science outcomes, and warned that learners may not recognize cross-disciplinary connections on their own. Rich concrete settings can even hide the abstract structure needed for transfer. The committee recommended explicit connections, support for knowledge within each discipline, and restraint about how much is integrated at once (National Academy of Engineering & National Research Council, 2014). A teacher should therefore name the equation inside the ballet activity, compare it with another representation, and later remove the ballet cues.

Integrated instruction also needs room for genuine science and writing. In a ballet sequence, collecting rehearsal times and checking a timing prediction is science when the student states assumptions, measures repeated trials, and explains discrepancies. Explaining why an equation fits the data is writing as reasoning. Calling any mention of movement "science" or any caption "writing" would make the cross-disciplinary claim less credible.

Personal interests and choice can create an entry point

Walkington (2013) randomly assigned 145 ninth-grade Algebra I students to standard or interest-personalized problems in one tutoring-system unit. Students receiving personalized contexts worked faster and more accurately within the unit. The strongest reported gains concerned translating situations into symbolic equations and students who had been struggling in that environment. After personalization was removed, that group continued to show advantages on ordinary problems with more complex structures. This study closely supports the idea of using ballet as an entry to algebraic representation. It does not establish that any chosen word, any algorithm, or a complete individualized course will have the same effect.

Choice also matters, but the claim should stay specific. Patall, Cooper, and Robinson's (2008) synthesis of 41 studies found positive effects of choice on intrinsic motivation and several related outcomes across child and adult settings. Hidi and Renninger's (2006) interest model describes how an initial situational interest may deepen when conditions sustain engagement and growing knowledge. Neither source proves that sorting words into three categories improves algebra. In Tiny Orange, the word sort is a proposed way to give learners a meaningful say while revealing what matters to them. Its educational value must be tested through engagement and learning outcomes, not inferred from the attractiveness of the interface.

Writing helps students learn mathematics and science

Writing is more than a way to report an answer. Graham, Kiuahara, and MacKay (2020) synthesized 56 experiments in grades 1–12 and found that writing about content improved learning in science, social studies, and mathematics by an average effect size of 0.30. The IES algebra guide likewise recommends precise mathematical language, comparisons among representations, analysis of worked examples, and explanations of strategy (Star et al., 2015). Tiny Orange can use short written or dictated explanations to reveal whether a learner knows what variables mean, where the quantities came from, and why a procedure works. Access to speech-to-text or an oral draft can support the writing process, while the final explanation remains a deliberate learning target.

Arts connections are plausible but age and content matter

An arts-integration trial summarized by the American Institutes for Research reported positive early mathematics outcomes in prekindergarten and kindergarten after teachers received sustained support in dance, music, and drama integration (Ludwig et al., 2016). That finding supports the plausibility of arts as a mathematics setting; it does not test adolescent algebra or prove that ballet alone raises algebra grades. Leonard and Bannister (2018) describe a middle-school dance strategy for geometric transformations, but their article is a pedagogical account

rather than an outcome trial. Tiny Orange’s ballet pathway should therefore be assessed as a new application, with real ballet content and an explicit algebra target.

The Tiny Orange word and category model

The proposed sequence gives learners two independent choices: the interest word and the initial academic category. They may choose supplied words, create their own list, or ask for automatically generated suggestions. They sort candidate words under mathematics, science, or writing. The same word may appear in all three because these labels identify a question to explore, not a permanent property of the word. Suggested categories should remain editable by the learner and teacher. Automatic generation supplies options; it does not decide what a student cares about or diagnose a learning difficulty.

Learner word	Mathematics entry	Science entry	Writing entry
Ballet	Count phrases and model rehearsal time	Test timing predictions across repeated runs	Explain the model and defend revisions
Gardening	Model bed area and planting intervals	Compare growth under controlled conditions	Write a claim using measured evidence
Music	Represent tempo and repeated patterns	Investigate sound frequency and vibration	Describe a method and interpret a graph

Before instruction, the teacher records the specific academic target and a baseline task. Recursive Skip Logic, Tiny Orange’s proposed adaptive process, then routes the learner according to evidence: advance after demonstrated understanding; revisit with a different representation after a conceptual error; reteach a prerequisite when needed; or try another chosen context if the first one obscures the idea. These are proposed decision rules, not empirically established properties of a software system. The target and success criteria remain visible to the learner and family throughout the route.

Bijou learns algebra through ballet

Suppose Bijou has repeatedly failed Algebra I tasks that require turning a situation into a linear equation. The phrase “terrible at algebra” describes the current record, not her capacity. Repeating the same explanation and worksheet without identifying the error would make the instructional response part of the problem. Bijou selects “ballet” and places it under mathematics. The teacher chooses the target “write, solve, and explain a two-step linear equation” and invites Bijou to arrange a short sequence of actual ballet movements with a four-count preparation followed by eight counts for each choreographic phrase.

Bijou and the teacher rehearse the phrase, count aloud, and use a metronome set to 120 beats per minute. With one count per beat, a sequence of p phrases contains $C = 4 + 8p$ counts. If the planned sequence has 52 counts, then $52 = 4 + 8p$, so $48 = 8p$ and $p = 6$. At the assumed constant tempo, 120 beats per minute is two beats per second, and the predicted duration is $52 \div 2 = 26$ seconds. The student can make a table, graph C against p , and explain that 4 is a starting quantity while 8 is the increase per phrase. Those quantities come from the choreography, not from a generic word problem decorated with a tutu.

For the science connection, Bijou times several full runs, compares the measurements with 26 seconds, and checks whether changes in tempo, pauses, or the one-count-per-beat assumption explain differences. The measured duration may vary; the algebraic count model is exact under its assumptions, while the time prediction depends on how the sequence is performed. For writing, she produces a brief explanation of what p and C represent, why subtraction precedes division, and how a measurement can disagree with a model without making algebra “wrong.” The teacher models this reasoning explicitly and uses errors as evidence for the next instructional route.

The transfer check removes ballet. For example: “A service charges a \$7 starting fee plus \$3 per hour. The bill is \$22. How many hours were used?” Bijou must form $7 + 3h = 22$, solve $h = 5$, identify the units, and explain the common structure without a choreography prompt. A later assessment repeats the check with new numbers and a new setting. The intended result is independent algebra performance; it cannot be claimed until these checks show it.

Implementation and evaluation

A small pilot should separate engagement from achievement. Before a unit, collect a brief concept inventory, an equation-writing task, and a student interest and confidence report. During instruction, record the chosen word, category, representations used, error patterns, route changes, time spent, accessibility supports, and completed work. Afterward, use three kinds of algebra item: the chosen context, an unfamiliar context, and a context-free equation. Reassess after two to four weeks. Score mathematics for accuracy and explanation, science for the quality of the test and interpretation, and writing for clarity of claim, evidence, and reasoning. Set mastery criteria before looking at results.

To evaluate the design fairly, compare a pilot group with learners receiving equally intensive algebra instruction, ideally with assignment at the class or student level when feasible. Track the same outcomes and instructional time, and report who benefits and who does not. A one-student narrative such as Bijou’s can show how routing works, but cannot establish the program’s effectiveness. A credible claim would specify the age group, algebra target, assessment, comparison, and size and durability of any observed improvement.

The approach has practical limits. Some interests do not yield a natural connection to every target; teachers should choose a different context rather than force a false analogy. Some

learners may prefer a direct algebra lesson or a quiet visual model over movement. A word list is an invitation to choose, not an obligation to disclose a personal passion. Integrated tasks can overload attention, so the teacher should limit simultaneous demands, teach unfamiliar ballet or science vocabulary as needed, and provide accessible ways to participate. These choices are particularly relevant for learners whose attention, sensory, language, or motor needs change which route is usable; diagnostic labels alone cannot tell us which route will work.

Conclusion

The literature supports teaching mathematics, science, and writing in connected work when the connections are explicit and each discipline has a real learning target. Personalized algebra contexts and writing to learn have direct evidence; integrated STEM and arts research add qualified support. Tiny Orange's contribution is the proposed learner-controlled word and category entry, followed by adaptive instruction and a transfer check. Bijou can learn algebra through ballet if the teacher teaches the algebra in the choreography, names and practices its structure, and verifies that Bijou can use it elsewhere. Her ability to pass algebra is the outcome to measure, not a conclusion to print in advance.

References

- Graham, S., Kihara, S. A., & MacKay, M. (2020). The effects of writing on learning in science, social studies, and mathematics: A meta-analysis. *Review of Educational Research*, 90(2), 179–226. <https://doi.org/10.3102/0034654320914744>
- Hidi, S., & Renninger, K. A. (2006). The four-phase model of interest development. *Educational Psychologist*, 41(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4
- Leonard, A. E., & Bannister, N. A. (2018). Dancing our way to geometric transformations. *Mathematics Teaching in the Middle School*, 23(5), 258–267. <https://eric.ed.gov/?id=EJ1177859>
- Ludwig, M., Marklein, M. B., & Song, M. (2016). Arts integration: A promising approach to improving early learning. American Institutes for Research. <https://www.air.org/resource/report/arts-integration-promising-approach-improving-early-learning>
- National Academy of Engineering & National Research Council. (2014). STEM integration in K–12 education: Status, prospects, and an agenda for research. National Academies Press. <https://doi.org/10.17226/18612>
- Patall, E. A., Cooper, H., & Robinson, J. C. (2008). The effects of choice on intrinsic motivation and related outcomes: A meta-analysis of research findings. *Psychological Bulletin*, 134(2), 270–300. <https://doi.org/10.1037/0033-2909.134.2.270>
- Star, J. R., Caronongan, P., Foegen, A., Furgeson, J., Keating, B., Larson, M. R., Lyskawa, J., McCallum, W. G., Porath, J., & Zbiek, R. M. (2015). Teaching strategies for improving algebra knowledge in middle and high school students. Institute of Education Sciences. https://ies.ed.gov/ncee/wwc/docs/practiceguide/wwc_algebra_040715.pdf
- Walkington, C. A. (2013). Using adaptive learning technologies to personalize instruction to student interests: The impact of relevant contexts on performance and learning outcomes. *Journal of Educational Psychology*, 105(4), 932–945. <https://doi.org/10.1037/a0031882>

Zhou, S., Dong, Z., Wang, H. H., & Chiu, M. M. (2025). A meta-analysis of STEM integration on student academic achievement. *Research in Science Education*, 55, 1273–1302. <https://doi.org/10.1007/s11165-024-10216-y>