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Learning Doesn't STEM from Worksheets: Why STEM Learning Starts Beyond Paper and Pencil Tasks

Rebecca Horrace[a], Brian Stone[b]

[a]*University of Colorado, Colorado Springs;* [b]*Northern Arizona University*

Rebecca Horrace holds both her Bachelor's and Master's in Elementary Education from Northern Arizona University, along with her Reading Specialist and Structured English Immersion Endorsements. She has taught elementary school, ran a homeschool cooperative program, and founded a 4-H club for military youth. She is currently a Lecturer of Literacy Methods for the University of Colorado, Colorado Springs. Rebecca also contributes to the Play in Education Newsletter, which is a quarterly publication that advocates for play in the classroom. She is currently serving as Editor. She also homeschools her two children, from whom she gains all her playful inspiration. She is a Play Ambassador and Expert Contributor for the Genius of Play (a non-profit website devoted to play advocacy), which is a part of The Toy Association. Rebecca is also finishing her Doctorate in Education with Indiana University in the Literacy, Culture, and Language Education program with a research focus on the intersection of play and popular media with literacy components while utilizing technology to expand the definition of local by converting distant interactions into a common, shared space. It is Rebecca's passion to reignite the dwindling spark between play and education along her career journey.

Brian Stone is an Associate Teaching Professor at Northern Arizona University. He is the faculty lead for the Professional Development School program and the Museum of Northern Arizona Partnership program at NAU. He received his Doctorate in Curriculum and Instruction with a content concentration in science and math education. He also holds two master's degrees, one in elementary education, and another in World War II studies. He teaches both undergraduate and graduate courses. Dr. Stone specializes in science education, but also teaches methods courses in social studies, math, literacy, and assessment. While at NAU, Dr. Stone has led multiple study abroad trips all around the world to study multiage education and integrated curriculum. He has taken students to New Zealand, Australia, the United Kingdom, Ireland, Germany, Austria, Switzerland, and France. Dr. Stone also serves as the editor for the STEAM section of the International Journal of the Whole Child. He is a Play Ambassador and recurring Expert Contributor for the Genius of Play (a non-profit website devoted to play advocacy), which is a part of The Toy Association. Dr. Stone has many areas of expertise and interests including scientific inquiry, play, integrated curriculum, and multiage education. Prior to teaching in higher education, Dr. Stone served as a 4th, 5th, and 6th grade multiage teacher. He was the lead multiage teacher in his school and helped other multiage teachers in their implementation of multiage strategies in the classroom. He also works as an educational consultant, traveling all over the United States and around the world helping schools with multiage programs. Dr. Stone has authored many peer-reviewed journal articles and book chapters in the aforementioned areas.

Abstract

The purpose of this article is to critically examine the use of worksheets in STEM classrooms from a whole-child, constructivist perspective. Teachers continue to rely on worksheets for STEM lessons, rather than engaging children in experiential learning practices. The authors argue that teachers must reexamine the role of worksheets in their classrooms and foster activities that deepen student understandings, cater to development, provide for differentiation, and provide engaging real-world/relevant experiences. With a focus on STEM education, the authors provide appropriate child-centered practices for educators to utilize as an alternative to worksheets. Some suggestions include inquiry-based activities that foster student interests, integrated real-world activities, authentic assessments, centers, projects, and play in STEM.

Keywords: STEM, play, worksheets

Introduction

Worksheets are commonly used in American classrooms to provide individual practice with specific skills, to supplement activities, and to assess student knowledge. Teachers often rely and depend on worksheets as an instructional tool, but rarely stop to question if the practice itself is a worthwhile endeavor. In other words, worksheets are a fully accepted practice and an expectation for most classrooms, but any critical analysis of worksheets and their dominant usage in education is rare. STEM environments are not immune to the overreliance on worksheets as children endlessly complete menial math and science tasks on paper. From a child-centered, whole-child, and constructivist perspective, this dominant practice needs to be critically reexamined. Worksheets often take the place of or reduce experiential learning activities, where children can build stronger, longer-lasting conceptual understandings. Worksheets also make differentiation across a variety of developmental levels and a range of understandings nearly impossible as they tend to push a singular objective in a standardized manner, not capturing the range and diversity of student interests and abilities. Furthermore, worksheets cater to obsolete societal skills that prioritize compliance, convergent thinking, superficial memorizations, and low-level mechanical skills. Therefore, it is the purpose of this paper to critically examine worksheets (especially in STEM environments), to provide a counter argument for their commonly accepted benefits, and to offer alternative suggestions for activities that cater to different student interests, developmental levels, and provide more meaningful/relevant experiences for children.

Yildirim (2011) explains, "worksheets are materials by which students are given transaction steps regarding what they are supposed to learn" (p. 45), where students fill in a box or answer a question based on specific evaluation criteria. Often, these steps are prescribed and standardized despite the plethora of evidence to suggest students have a substantial range of abilities and understandings. Many worksheets, perhaps most, fall into the busywork or "busy sheet" category where students complete "low-level recall, filling in blanks with words, choosing from multiple choice questions, labeling things - or work that has no educational value at all" (Gonzales, 2018, para. 11). When evaluating STEM curriculum, educators need to place an emphasis on students' learning, inquiry, and application of knowledge, as well as their engagement, which are all supported by active involvement and exploration, rather than the passive compliance of filling out worksheets.

Educators should adopt a critical lens when considering worksheets as an instructional tool, and at the forefront, teachers need to account for the continuum of child development in their classrooms. The range of academic abilities in a typical public-school classroom can span five or more grade levels (Bondie et al., 2019; Hertberg-Davis & Brighton, 2006), yet a worksheet provides a one-size fits all approach (Latz et al., 2008), covering only the grade-level curriculum, and cannot accommodate all learners (Segar, 2021). Attempting to use a singular tool, such as a worksheet, to drive instruction and assess student understanding is inappropriate and often out of alignment with the range and diversity of human intelligence represented in the typical classroom. For example, using a multiplication worksheet after a lesson on multiplication can cause high levels of frustration for students who are still struggling to understand addition. Furthermore, students who have already mastered multiplication and who are ready to learn more advanced concepts need additional opportunities. Worksheets, along with their prescribed standardized expectations and learning outcomes, are inappropriate practices to support student learning and engagement, and do not represent authentic assessments of student learning.

Worksheet Usage in the Classroom

"*If they can do the worksheet, they don't need it. If they can't, it won't help them.*" –Marilyn Adams

The above quote from Marilyn Adams, a cognitive and developmental psychologist, presents a profound and substantial truth. If students can easily complete the worksheet, then it is indeed a "time-filler." Yet, for those children struggling to complete the worksheet, any length of time and effort ends up being in vain as the worksheet will not help with their understanding or knowledge retention in any way. A worksheet can be seen as a sheet in which students regurgitate a specific set of information, not a place where they showcase evidence of their understandings of a concept or a place where they build or apply critical thinking skills. Problem solving and critical thinking are pillars of the expertise needed to thrive in STEM classrooms and future careers.

Students learn best through active exploration as they engage in meaningful content that extends their knowledge and excites their desire to learn (Parker et al., 2022). Yet, Segar (2021) points out, "[worksheets] do not ignite a passion for learning" (para. 19). In fact, they often preclude interest-based explorations and limit intrinsic motivation as the only teaching method used is based on writing, lecturing, and filling out a corresponding sheet (Yildirim, 2011). Furthermore, "as worksheets tend to impose the theories on the students, this may affect the process of the students' knowledge construction" (Choo et al., 2011, p. 525), inhibiting students from critically thinking and engaging with content beyond surface level memorizations.

Within a "worksheet space" there is a continuum of possibilities, some more engaging than others. On one end of the spectrum, "busysheets" represent work that has little educational value and accomplishes the goal of filling time. On the other end of the spectrum, more engaging possibilities include graphic organizers, data collection tools, and planning webs. These options can be viewed as “powersheets” which directly support learning and may support other tasks as well (Gonzales, 2018). These “powersheets" are often open-ended, supplement more robust activities like science experiments, and provide opportunities for differentiation and student inquiry. However, educators should use caution because the worksheet can be a hindrance to genuine learning, and typically there is a more engaging way to complete an activity than relying on any type of paper and pencil task, even if it is open-ended.

With an ever-changing and constantly challenging landscape in our society, children are often exposed to increased amounts of stressors (Gray et al., in press). Coupling life stress with school stress creates a very unhealthy imbalance for children, and these school stressors can occur when inappropriate teaching methods are practiced. As Burts et al. (1990) defined “examples of inappropriate practices are: rote-learning; abstract paper-and-pencil activities; and direct teaching of discrete skills, often presented to large groups of children” (p. 408). These practices can cause further stress regarding timely completion and accuracy as students focus heavily on “fitting in the box” as opposed to feeling confident in thinking divergently and operating through intrinsic motivation. Children need to have the opportunity to make their own decisions, feel valued and heard, and participate in their education as they develop agency. “If children are to grow up well-adjusted, they need ever-increasing opportunities for independent activity, including self-directed play and meaningful contributions to family and community life, which are signs that they are trusted, responsible, and capable” (Gray et al., in press). Worksheets, especially when they dominate classroom time and then go home as homework, create undue stress, push extrinsic motivators, and do not even lead to any sort of meaningful boost in achievement (Lee, 2014).

Reevaluating Worksheets as a STEM Instructional Tool

The consistent use of worksheets in STEM environments creates an effect where students feel they must conform to specific answers in order to be “right” where any other response is viewed as “wrong.” Furthermore, students often feel uncomfortable with more open-ended explorations in science, and “are often presented with highly detailed laboratory instructions that have been carefully designed and tested to produce a desired outcome” (Nunes et al., 2022). While these scripted procedures can have some value, they often do not represent true scientific exploration of unknown phenomena (Nunes et al., 2022). Worksheets contribute to this dominant culture of scripted procedures in STEM subjects, while conditioning children to adhere to the script and motivating them to conform for a grade. Students come to realize the ultimate goal–to provide the correct answer (Anderson, 1981; Slavin, 1983). If they have the right answer, students tend not to care “why and how the answers were generated” (Wu & Huang, 2007, p. 745), which is the exact opposite goal of STEM education, where innovators, thinkers, collaborators, creators, and inventors need to understand the “why” and “how” as they develop into future astrophysicists, coders, architects, and roller coaster designers.

In worksheet-heavy STEM environments, students become reliant on their teachers to provide scripted procedures and the answers at the end. This can, in turn, affect their ability to develop a personal identity as a scientist, mathematician, or engineer, for example (Stone, 2022). Instead, students view the teacher as the expert (e.g., the scientist) and they await their instructions, rather than taking ownership of their learning and hindering their agency to take on the role of scientist. These types of scripted explorations that are aided by worksheets often put children in a box and are antithetical to real-world STEM explorations that require problem-solving skills, critical thinking, innovation, and a willingness to step into the unknown.

Instead, as teachers seek to inspire inventors and creators, children need to know that each trial or failure is part of the path to their success. By taking away the predetermined, correct answer sheet, educators make room for students to engage in conversation with one another, discuss outcomes, question each other, and self-assess to become “aware of their learning” (Wu & Huang, 2007, p. 740). Allowing for instructional flexibility apart from worksheets can open student-initiated dialogue that perhaps deviates from the main topic, but ventures into a whole new area of educational content, one that would not have been possible with a strict adherence to completing the worksheet. No longer should students be expected to passively fill out worksheets (Broadbent, 2021; Browne, 2020), but rather they can actively participate in experiential learning opportunities ignited by real-time interactions and hands-on engagement (Segar, 2021).

Hartini et al. (2020) used worksheets for STEM learning and activities as part of a study to train students’ critical learning and identified eight critical thinking indicators including: giving explanations, formulating questions, formulating answers, reporting experiment results, analyzing experiment results, concluding investigation results, concluding calculation results, and deciding actions. The results concluded seven out of eight critical thinking indicators of students’ evaluation were measured as only “sufficient.” The goal is for students to be strong in the areas of critical thinking, creativity, and exploration, not just “sufficient” and able to pass a test or complete a worksheet; rather they should be capable of questioning, reasoning, and evaluating on their own.

When relying on pre-scripted worksheets, there is very minimal flexibility that can occur within teaching strategies and activities as “the implementation of lesson plans cannot be separated from the usage of the student worksheets” (Hartini et al, 2020, p. 4), which can lead to issues with student comprehension and concept development if there is no flexibility to deviate away from “the script.” Considering the surface-level, memorized information worksheets foster (Stone, 2020), they bring little value for student assessment. It should be noted that worksheets are not a form of authentic assessment (Frey et al., 2012) due to their restrictive nature in predetermined response structure. When looking for authentic student assessments, it is vital to consider the experiential aspect and evaluate how students are involved in showcasing their understanding by analyzing key components such as the following questions:

- Are students able to “do” the subject?
- Are students replicating or operating in real-world contexts?
- Are students able to efficiently and effectively use a repertoire of knowledge and skills to negotiate complex tasks?
- Are students receiving ample feedback?
- Are students able to showcase their product/result with their peers or community members?

When designing authentic assessments for STEM, educators must rethink their usage of sterile, disconnected, inauthentic tools like worksheets. Instead, they must design meaningful, relevant, performance-based activities that are situated in real-world contexts where students must problem-solve, actively apply their knowledge, and embrace uncertainty. For example, imagine a student conducting an experiment on several plants to determine what environmental elements help them grow and thrive the best. Perhaps another student codes a new ending for their favorite video game. A budding engineer, who loves thrill rides, creates a roller coaster from a building system of interlocking rods, connectors, blocks, gears, and wheels, and then submits their idea to a theme park creativity submission contest. Another example is the mathematician who loves space and develops a safe path for a satellite to orbit, all as part of their STEM activities in the classroom. Rather than answering "true" or "false" on a worksheet, these students *experience* what is "true" and "false" as they interact with concepts and develop a deep understanding of their content matter, hyper-engaged in their learning.

Moving Toward a Constructivist Lens

STEM curriculum should align with a constructivist approach in which learners are engaged in and construct their own meaningful knowledge through play, inquiry, and exploration. The focus should be on the child (or learner); where once seen as passive, constructivism appreciates a child's "active application of ideas to problems" (Ertmer & Newby, 1993, p. 62). As Wilson (2018) explains, "a typical example of constructivist instruction presents a complex problem or challenge within a resource-rich environment, with learners working together and assuming responsibility for activities and decisions, and teachers in a support role" (p. 61) mentoring their learners as the students take charge and collaboratively work through real-world problems, as they naturally occur. Further supporting the move away from dry, teacher-centered instruction (i.e., classrooms that rely heavily on worksheets) to fostering actively engaged learners, the National Science Teaching Association (2018) recommends that teachers "[nurture] the wonder, enthusiasm, and curiosity of children by creating an environment" that fosters "exploration and discovery," and one that actively engages children in their own investigations (Declarations, para. 6). Furthermore, NSTA recommends "[considering] development and learning…while [providing] authentic formative… assessments" (Declarations, para. 2).

Drawing from Wilson's (2018) extensive look into specific attributes that constitute constructivist learning/teaching, three basic precepts include:

- Learning is an *active process of meaning-making* gained in and through our experience and interactions with the world.
- Learning opportunities arise as people encounter *cognitive conflict or challenge*, and through naturally occurring as well as planned *problem-solving* activities.
- Learning is a *social activity* involving collaboration, negotiation, and participation in authentic practices of communities. (p. 61)

Considering the nature and possibilities of child-led STEM explorations, it is vital to align curriculum to the pillar of constructivism in order to enhance children's creative avenues as they draw on their previous knowledge to construct new knowledge because "to repress interest is to substitute the adult for the child, and so to weaken intellectual curiosity and alertness, to suppress initiative, and to deaden interest" (Dewey, 1897, p. 79).

Methods for Teaching STEM

Considering "students learn best when they are actively engaged in their learning through direct experience, reflective thinking, and social interactions" (Mchenry et al., 2017, p. 60), it is evident worksheets do not support these learning goals since they are passive in nature, prescriptive, and do not accommodate diverse learners. The National Science Teaching Association (2018) recommends three-dimensional teaching that includes the following attributes:

- An educational environment that supports "creative and in-depth learning," and opportunities to engage in STEM through real-world, relevant applications that are driven by student interest.
- Students engage in science and engineering practices over time while developing conceptual understandings and move from curiosity to interest to reason (Moulding, Bybee, & Paulson, 2015). Students become scientists "as they plan and carry out investigations, solve problems, create models, analyze and interpret data, construct explanations, and design solutions."
- Adequate time for active science investigations that involve the processes of science. (paras. 6-9)

It is difficult to reconcile traditional, passive tasks like worksheets with the NSTA recommendations for dynamic, three-dimensional teaching methods. According to the Engineering in Education branch of the Museum of Science (2020), America's future workforce will be significantly impacted by a "pace of innovation [that] is so rapid that new technologies of today may be obsolete in just a few years," while "65 percent of the jobs that today's K-6 children will hold haven't even been invented yet" (para. 1). Their recommendation is for instruction to be rooted in the Engineering Design Process that encourages children to be "problem solvers, critical thinkers, communicators and collaborators" (EiE, 2020, para. 4).

Worksheets could certainly be used to supplement active practices and investigations, but too often they are used to replace those activities. Furthermore, the worksheet was designed to reinforce the skills of yesterday including rote memorizations, simple transfers of information, and encouraging isolated, discrete learning outcomes that are often disconnected from any meaningful contexts. As the EiE (2020) noted, the skills of tomorrow will require students to think beyond these simplistic time killing tasks. Students must learn to problem-solve and innovate in a complex, interconnected world. The worksheet often teaches the student that there is one right answer, that there is always a scripted procedure (designed by someone else), and that the goal/motivation is a grade rather than the actual learning process.

Even in the realm of mathematics, which overall has been a long-standing holdout in the move towards a more progressive, child-centered approach, researchers found that experiential learning as related to real-world, relevant topics positively impacted student attitudes towards math and boosted their academic achievement (Uyen et al., 2022). Larbi and Mavis (2016) suggest that "typical mathematics instruction… consists of listening to teacher explanations, watching him solve problems on the chalkboard using a mathematics textbook, and working alone to solve problems on worksheets" (p. 54). However, in their study, they found that the use of manipulatives significantly improved students' mathematical thinking and performance (Larbi & Mavis, 2016). In addition, the National Council of Teachers of Mathematics (n.d.) suggests that educators of "STEM education within the mathematics program, look for opportunities to integrate science, technology, and engineering in meaningful ways as students tackle problems involving mathematics in relevant settings" (para. 16).

Therefore, when considering ways to teach experiential STEM activities, it is important to consider pedagogical practices that support inquiry, the whole-child, development, and relevant, active projects. Inquiry and interest-based explorations should be a guiding force in STEM investigations. Also, meaningfully integrated, real-world, relevant contexts should be used as the setting for STEM activities. Teachers should emphasize problem-solving skills, social interaction and collaboration, concrete representations to build conceptual understandings, critical thinking, and research skills. The authors' recommendation is for educators to move away from worksheets entirely to a dynamic, three-dimensional teaching approach. Strategies like choice-based centers, student-led projects (i.e., project approach), problem-based learning, and small group instruction can be very effective to accomplish these goals.

As Schmidt et al. (2011) agreed, "students [involved in these strategies] are more independent learners and take more personal responsibility for their learning" due to the nature of their open-ended, project-based learning opportunities. These strategies deemphasize obtaining the correct answer and focus on the students' learning process. Students are involved in the entirety of their learning from the beginning, as they "are required to come up with tentative theories to explain the phenomena presented in the problem" (Choo et al., 2011, p. 524), work through their theories, testing and analyzing, and then forming their conclusions.

Play in STEM–a Perfect Pairing

Just as children develop their literacy understanding from birth, children also form their understanding of STEM concepts from an early age (Kennedy & Tunnicliff, 2022), and since children's key mode for gathering knowledge is through exploration of their world, it is natural to incorporate play into STEM activities. Educators should encourage children to tinker with toys versus providing an endless parade of paper and pencil tasks. A recent fad that is catching on in education programs is to use "educational toys" that push learning (with specific objectives) through play. Educators might use terms such as "child's work" and "tools" rather than play and toys (Chudacoff, 2007). This practice is especially prevalent in STEM, but it is important that educators (and parents) hold on to the true value of play (authentic, self-chosen, self-directed) because this type of thinking is the exact opposite of what child-led play truly entails. As Almqvist (1994) noted,

> Children do not say "Now I'll improve my thinking by means of constructional play." Or "Now I'll play something that can develop my creativity." They just play, and usually they do not do one instead of the other. Rather, they say, "Let's take all the blocks and pretend we build the highest house in the world." (p. 65)

Children do not critically examine how they play; they *just play*. Furthermore, as Gray et al. (in press) and most parents and educators can agree, "play is a direct source of children's happiness," so it makes sense to pair their favorite pastime with the very hands-on, engaging curricula of STEM.

As opposed to utilizing worksheets for STEM instruction, educators can prioritize authentic play as a mode for student learning because "through constructive play, children explore science in action, use mathematics through counting and comparing sizes and shapes, apply their imagination and curiosity by creatively exploring the world around them, and cooperate and communicate their understandings of their own environment" (Kennedy and Tunnicliffe, 2022, p. 6). For example, students demonstrate their understanding as they play with magnetism, understanding when and how to apply their knowledge to construct bridges using magnetic tiles to hold specific weights, calculating measurements along the way. Ample exploratory activities and play opportunities are important for children as "they have chosen to pursue an activity for a reason, and typically the experience is interesting or pleasurable" (Stone, 2016, p. 6). These experiences create meaning for the child to continue exploring and analyzing, as opposed to filling in pre-scripted worksheets that bear little importance for the child. Furthermore, children's play is their way to work through their problems and negotiate their feelings and surroundings. Therefore, pairing play and STEM not only "promotes comprehension, but it also provides opportunities for children to become socially, physically, emotionally, and even culturally involved" (Stone, 2016, p. 1).

Play in STEM curriculum allows children to construct and interact as they naturally "learn by *making sense out of the world*" (Wilson, 2018, p. 61). When children engage in playful learning, they play what they know as they "draw upon their imaginations and their lived experiences and to tap into their passions and expertise" (Wohlwend, 2011, pp. 2-3). A child who loves airplanes may want to learn about forces and tinker with the aerodynamics of paper airplane construction, while a child fascinated by chemistry may want to develop their own unique slime concoction. In both examples, the educator does not need to force their knowledge onto a pre-scripted sheet of paper, but rather foster the organic, natural process of inquiry through experimentation. As Stone (2016) agrees, "play in science is a necessary and beneficial element of childhood, and it should be treated as such" (p. 9), which is why educators should consider play over worksheets for authentic, engaging, experiential STEM teaching practices.

Granting students the freedom and independence to follow their inquiries and choose their activities (at least to some extent), which includes how they will play their way through their learning, is a vital benefit to our children's whole-self and well-being. Children need to know they have ownership in *what* they learn and *how* they learn because "a primary cause of the rise in mental disorders is a decline over decades in opportunities for children and teens to play, roam, and engage in other activities independent of direct oversight and control by adults" (Gray et al., in press). Allowing our students to propose a STEM interest and then providing them the reins to follow through with corresponding activities or experiments, as opposed to teacher-driven worksheets, not only promotes their STEM education foundation, but also their self-worth and agency. All the key components and "elements for developing STEM capital and promoting active citizenship, and a scientifically literate workforce, begin with young children and revolve around play" (Kennedy & Tunnicliff, 2022, p. 23). With continued support from parents and educators, when children are encouraged to imaginatively play, they can build a solid STEM foundation (Horrace, 2021).

Conclusion

Worksheets have, over the decades, become a dominant instructional practice in American schools. A typical public school uses on average about 2,000 sheets of paper per day, and with over 100,000 schools in the United States, it is estimated that schools are consuming about 32 billion sheets of paper per year (McHugh, 2022). Not only does this represent an environmental catastrophe, but educators must re-examine whether worksheets are worth the time and material resources. As STEM education continues to move in the direction of an integrated, context-rich, child-centered, inquiry-based, and three-dimensional direction, classroom practice needs to evolve as well. Educators need to reconsider their usage of worksheets and move toward well-planned activities that foster student interest, active investigations, and relevant experience. The drawbacks of worksheets are evident, but educators rarely critique the practice. Children cannot afford to waste significant time on empty instructional tools that support passive learning. Rather, teachers should focus on strategies that engage and foster insightful, creative learners who question big ideas and want to know more about the world around them.

References

Almqvist, B. (1994). *Toys, play, and child development: Educational toys, creative toys*. Cambridge University Press.

Anderson, L. M. (1981). *Student response to seatwork: Implications for the study of students' cognitive processing.* Paper presented at the Annual Convention of the American Educational Research Association, Los Angeles, April, 1981.

Bondie, R., Dahnke, C., & Zusho, A. (2019). How does changing "one-size-fits-all" to differentiated instruction affect teaching. *Review of Research in Education*, *43*(1), 336-362.

Broadbent, K. (2021). Active vs. passive learning: What's the difference. *Melio*. https://www.melioeducation.com/blog/active-vs-passive-learning/

Browne, M. (2020). Active vs. passive learning: "At the intersection" of home and school with prepared parents' Mira Browne. *Marshall Street*. https://www.marshall.org/active-vs-passive-learning-with-prepared-parents/

Burts, D., Hart, C., Charlesworth, R., & Kirk, L. (1990). A comparison of frequencies of stress behaviors observed in kindergarten children in classrooms with developmentally appropriate versus developmentally inappropriate instructional practices. *Early Childhood Research Quarterly*, *5*, 407-423.

Chudacoff, H. P. (2007). *Children at play: An American history.* New York University Press.

Choo, S. S. Y., Rotgans, J. I., Yew, E. H. J., & Schmidt, H. G. (2011). Effect of worksheet scaffolds on student learning in problem-based learning. *Advances in Health Sciences Education, 16*, 517-528. https://doi.org/10.1007/s10459-011-9288-1

Dewey, John. (1897). My pedagogic creed. *School Journal, 54*, 77-80. https://doi.org/10.1177/002205742510101803

Engineering in Education (2020). Game-changing integrated STEM. *Museum of Science*. https://eie.org

Ertmer, P., & Newby, T. (1993). Behaviorism, cognitivism, constructivism: Comparing critical features from an instructional design perspective. *Performance Improvement Quarterly*, *6*(4), 50-72.

Frey, B., Schmitt, V., & Allen, J. (2012). Defining authentic classroom assessment. *Practical Assessment, Research, and Evaluation*, 17, Article 2. DOI: https://doi.org/10.7275/sxbs-0829

Gonzales, J. (2018). Frickin' packets. *Cult of Pedagogy*. https://www.cultofpedagogy.com/busysheets/

Gray, P., Lancy, D. F., & Bjorklund D. F. (in press). Decline in independent activity as a cause of decline in children's mental wellbeing: Summary of the evidence. *The Journal of Pediatrics.* https://doi.org/10.1016/j.jpeds.2023.02.004

Hartini, S., Mariani, I, Misbah, & Sulaeman, N. (2020). Developing of students worksheets through STEM approach to train critical thinking skills. *Journal of Physics: Conference Series*, 1567, DOI:10.1088/1742-6596/1567/4/042029

Hertberg-Davis, H., & Brighton, C. (2006). Support and sabotage principals' influence on middle school teachers' responses to differentiation. *Journal of Secondary Gifted Education*, *17*, 90-102.

Horrace, R. M. (2021). STREAM into online play groups: How children adapt to play in a rapidly digitized world. *International Journal of the Whole Child, 6*(1), 78-87.

Kennedy, T. & Tunnicliffe, S. D. (2022). Introduction: The role of play and STEM in the early years. In Kennedy, T. & Tunnicliffe, S. D. (Eds.), *Play and STEM education in the early years: International policies and practices* (pp. 3-37). Springer.

Larbi, E., & Mavis, O. (2016). The use of manipulatives in mathematics education. *Journal of Education and Practice, 7*(36), 53-61.

Latz, A., Speirs Neumeister, K., Adams, C., & Pierce, R. (2008). Peer coaching to improve classroom differentiation: Perspectives from project CLUE. *Roeper Review*, 31(1), 27-39.

Lee, C. (2014). Worksheet usage, reading achievement, classes' lack of readiness, and science achievement: A cross-country comparison. *International Journal of Education in Mathematics, Science and Technology, 2*(2), 96-106.

Mchenry, N., Borger, L., Liable-Sands, L. (2017). A novel approach to professional development in middle school science: Instructional coaching by university professors to improve the instructional core. *Journal of Curriculum and Teaching, 6*(2), 59-74.

McHugh, R. (2022). How much paper schools use & how much it costs them. *Record Nations*. https://www.recordnations.com/blog/how-much-paper-schools-use-how-much-costs/

Moulding, B., Bybee, R., & Paulson, N. (2015). *A vision and plan for science teaching and learning*. Essential Teaching and Learning PD.

National Council of Teachers of Mathematics (n.d.). Building STEM education on a sound mathematical foundation. https://www.nctm.org/Standards-and-Positions/Position-Statements/Building-STEM-Education-on-a-Sound-Mathematical-Foundation/

National Science Teaching Association. (2018). *NSTA position statement: Elementary school science.* https://www.nsta.org/nstas-official-positions/elementary-school-science.

Nunes, K., Du, S., Phillip, R, Mourad, M., Mansoor, Z, Laliberte, N., & Rawle, F. (2022). Science students' perspectives on how to decrease the stigma of failure. *FEBS Open Bio*, *12*(1), 24-37.

Parker, R., Thomsen, B.S., & Berry, A. (2022). Learning through play at school – A framework for policy and practice. *Frontiers in Education*, 7.

Schmidt, H., Rotgans, J., & Yew, E. (2011). The process of problem-based learning: what works and why. *Medical Education 45*, 792-806.

Segar, S. (2021). Why I don't give my students worksheets and what I do instead. Experiential Learning Depot. https://www.experientiallearningdepot.com/experiential-learning-blog/why-i-dont-give-my-students-worksheets-and-what-i-do-instead

Slavin, R. (1983). When does cooperative learning increase student achievement? *Psychological Bulletin*, *94*(3), 429-445.

Stone, B. (2016). Playing around in science: How self-directed inquiry benefits the whole child. *International Journal of the Whole Child, 1*(1), 1-10.

Stone, B. (2020). Curriculum-centered barriers to child-centered practice and frames for resistance. *Professing Education*, *18*(1&2), 51-64.

Stone, B. (2022). Holistic identity development in STEAM. *International Journal of the Whole Child*, *7*(1), 75-83.

Uyen, B., Tong, D., & Lien, N. (2022). The effectiveness of experiential learning in teaching arithmetic and geometry in sixth grade. *Frontiers in Education*, 7, 1-13x. https://doi.org/10.3389/feduc.2022.858631

Wilson, B. G. (2018). Constructivism, for active authentic learning. In R. A. Reiser & J. V. Dempsey (Eds.), *Trends and issues in instructional design and technology* (4th Ed.), (pp. 60-67). New York, NY: Pearson Education.

Wohlwend, K. E. (2011). *Playing their way into literacies: Reading, writing, and belonging in the early childhood classroom.* Teachers College Press.

Wu, H., & Huang, Y. (2007). Ninth-grade student engagement in teacher-centered and student-centered technology-enhanced learning environments. *Science Education*, *91*(5), 727-749.

Yildirim, N., Kurt, S., & Ayas, A. (2011). The effect of the worksheets on students' achievement in chemical equilibrium. *Journal of Turkish Science Education, 8*(3), 44-58.