Chapter 15
Multimodal Literacy and Creative Computing Badges in a Teacher Quality Partnership Residency Program:
Putting P–12 Students at the Center Right from the Start

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ABSTRACT

Introducing micro-credentialing into Lehman College's teacher residency program provides candidates with opportunities not afforded in Master's courses of study. Through the micro-credential offerings, residents learn to integrate literacy strategies and computational thinking across subject areas and grade levels. This chapter explores how micro-credentials validate non-credit "course" structures by linking content knowledge with pedagogy and theory with practice. The design and execution of both the micro-credentials described in the chapter make explicit connection between competencies and student learning.

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INTRODUCTION

Lehman Urban Transformative Education—Science, Technology, Engineering, and Mathematics (LUTE-STEM) is a federally funded Teacher Quality Partnership residency program. Each year for four years (2020–2024), up to 25 master's degree candidates from diverse backgrounds who are committed to integrating computer science and computational thinking into their disciplines and work in high-need urban settings are selected for a paid residency. Residents work as co-teachers in one of five partner schools, complete a master's course of study, and qualify for a New York State teaching certificate after passing all required state assessments.

Introducing micro-credentialing into Lehman College's teacher residency program provides candidates with opportunities and proficiencies not afforded in their master's courses of study. Through micro-credential offerings, residents learn to integrate multimodal literacy strategies, computer science principles, and design thinking across subject areas and grade levels. This case study explores the ways that micro-credentials validate non-credit "course" structures by linking content knowledge with pedagogy and theory with practice. The design and execution of both micro-credentials described below make explicit the connections between competencies and student learning.

BACKGROUND

Teacher Residencies

Field-based teacher preparation grounded in the realities of practice is not new. What is relatively new is the notion of teacher residencies. Teacher residency programs emerged over the last decade with significant support provided by the United States Department of Education in the form of Teacher Quality Partnership grants. An audit of teacher residency programs in 2016 revealed that there were at least 50 teacher residency programs across the nation (Guha et al., 2016) What do teacher residencies have in common? Paull et al. (2021) developed an operational definition that covers three major categories: curriculum, structure, and collaboration. Curricula, often tailored specifically for residents, weave theory into practice, focus on research-based best practices, and foreground culturally responsive/sustaining pedagogy. Structurally, residents are co-teachers rather than teachers-of-record, work alongside experienced mentor teachers, and spend either half days or full days in their placements across an entire school year. District partners co-construct the residency experience with higher education institutions with the intent of preparing a diverse pool of candidates who are, according to the latest parlance, ready to teach on day one.

Despite the paucity of empirical research, there is evidence that residency models compare favorably to traditional teacher preparation programs. Teacher residency programs have been able to recruit a diverse pool of candidates (Azar et al., 2020). In addition, graduates of residency programs are more likely to stay the course in high-need schools (NCEE Evaluation Brief, 2014, 2015). However, it is unwise to generalize about the effectiveness of teacher residencies. In their introduction to the special issue on Urban Teacher Residencies in *Urban Education*, Hammerness et al. (2016) highlighted case studies from New York City and San Francisco that underscore the importance of contextualizing both the curriculum and structure of residencies.

Micro-Credentials and Digital Credentials in Education

There is significant interest in digital credentials (often associated with digital badges) as a promising practice in recognizing skills necessary in a variety of work settings (Clements et al., 2020). Proponents in the education sector argue that this approach to professional learning is both unique and powerful because it is targeted (Kohl, 2019), individualized (Bartz & Kritsonis, 2019), learner controlled as to time of access, pace, and completion (NEA, n.d.), assessed (French & Barnett, 2017), and rewarded (Luke & Young, 2020). According to Pusey (2019) micro-credentials should not only be competency-based but also encourage application. Rehearsal of skills in a badging context increases the likelihood that teachers will implement the new skill(s) in the classroom; as a result, schools and school districts in at least 11 states provide continuing education units for completing micro-credentials (DeMonte, 2017). While badging is gaining in popularity as a way to document professional learning for in-service teachers, it is largely absent from the pre-service assessment/accountability systems mandated by external accreditation organizations.

All teacher education programs must evaluate how well their candidates demonstrate the knowledge, skills, and dispositions that are essential for beginning teachers. Might badging be an important way of documenting what future teachers know and are able to do? West-Puckett (2016) describes digital badging as a form of multimodal assessment:

Digital badging is an assessment technology that offers promise for providing a meaning-making system that operates on the principles and practices of open culture—a social movement that values collaboratively produced information and knowledge which is freely distributed and built on through accessible networks. Like traditional badges worn by scouts, civil servants, and military personnel, digital badges are graphics that symbolize achievement, experience, or affiliation in particular communities. In digital spaces, these web graphics are encoded with metadata that provide descriptive information about the badge issuer, the criteria for earning the badge, the date the badge was earned, and the evidence for artifacts that were submitted in consideration of the badge application. (p. 130)

In LUTE-STEM, digital credentials, operationalized as badges or nano-badges, first define specific skill paths that a teaching candidate is expected to follow. Nano-badges, a term coined specifically for the *Creative Computing* badge, divide the badge competencies into five smaller components, giving students encouragement to work their way through 32 projects. Once badges are achieved, the metadata in these graphic representations demonstrate specific achievements gained during the residency. Badges, while not a replacement for traditional accountability measures like course grades and standardized tests, become an important part of how residents introduce themselves to schools and to distinguish residency candidates from peers who also completed teacher preparation programs in the Lehman School of Education.

Design Thinking

We live in a rapidly changing, increasingly mobile, intensively technological, and interconnected world. How can we ensure that the next generation is ready to survive and thrive under these conditions? According to Luka (2014), design thinking has gained acceptance in both the for-profit and nonprofit sectors because it is a mindset that fosters innovation and creativity. Design thinking shares many features with

deeper learning competencies, identified by educators and employers as critical for success in school and the workforce (Zeiser, et al., 2014).

While there are some differences in the ways design thinking proponents describe the mindset, there is consensus around the notion that process is more important than product. This process is described as a series of steps that can be implemented in a cyclical rather than linear fashion. Significant attention is paid to collecting feedback from individuals who will be the end users of the innovation, looking at a problem from a variety of perspectives, and accepting the iterative nature of problem solving (Razzouk & Shute, 2012).

Noel and Liub (2017) argue that design thinking-based education—with an emphasis on curiosity, innovation, empathy, teamwork, and multiple perspectives—prompts a paradigm shift away from traditional approaches to teaching and learning. There is a growing body of research, largely based on case study data, that teaching K-12 students as well as teacher candidates to apply design thinking principles holds promise not only for increasing risk-taking, engagement, and cooperation in specific courses or classrooms but for transfer of these habits of mind to other academic and non-academic settings (Aflatoony & Wakkary, 2015; Androutsos & Brinia, 2019; Carroll et al., 2010).

Design thinking was foundational to the development of the LUTE-STEM micro-credentials described in this chapter. By focusing on the end user (such as K-12 students) as well as the intended audience (LUTE-STEM residents), encouraging reflectivity, and breaking down larger skills into "fundamental parts" (DeMonte, 2017), developers were exploring novel ways to on-board novice teachers. In addition, they were intentional about requiring residents to exercise elements of design thinking so that they could see how this mindset could inform instructional decisions.

MULTIMODAL LITERACY IN STEM: ONBOARDING RESIDENTS USING BADGES

Teacher consultants in the New York City Writing Project (NYCWP) were eager to create a summer workshop for the first cohort of LUTE-STEM residents at Lehman College in 2020. The consultants knew how to introduce young teachers to the theory and practice that has been central to their work with students and teachers in New York City Schools for over 40 years. As teachers of writing across the curriculum, the NYCWP was ready to provide residents with an introduction to multimodal literacy that they could use to more deeply understand how students use multiliteracies to acquire knowledge in STEM.

What no one knew when the consultants started to plan a series of workshops was that their work with the LUTE-STEM residents would be online because of the COVID-19 pandemic. Rethinking face-to-face workshops as online offerings became an opportunity to engage pre-service teachers in experiences where the medium and the message complemented each other. Multimodal learning experiences provided examples of what (and why) residents could bring to the classrooms where they would be co-teaching in the fall.

Thinking outside of the Zoom video lecture box, NYCWP consultants designed asynchronous workshops for the residents using two platforms that have had success in K-12 schools in recent years: NowComment (nowcomment.com) and LRNG (lrng.org).

NowComment affords the following:

- Close reading of text, images, and video;

- Annotations of sentences and paragraphs, selected areas of images, and specific timestamps in videos that become online conversations with peers;
- User-added sources to support their interest-based inquiries;
- Personal libraries of sources organized into collections and shared with peers for collaborative reading and analysis.

LRNG engages the learner with these resources:

- Online curriculum designed as "playlists" that engage youth in interest-based projects;
- Playlists available anytime and anywhere on computers, smartphones, or tablets;
- A choice of playlists—some designed locally, others created by educators across the country;
- Individual learning pathways that grow as youth pursue their interests;
- Digital badges to mark skills and knowledge;
- Digital portfolios that organize badges and show work to real audiences.

For the summer online LUTE-STEM workshops, NYCWP teacher consultants were careful to design experiences for the residents that would be inviting, give opportunities for deep dives around their areas of interest, and be equivalent to the number of hours they might spend in a daylong series of in-person workshops. The consultants developed two playlists for the residents to complete with each ending in an open, digital badge.

The first playlist, *An Orientation to Multimodal Literacy in STEM,* familiarized residents with two platforms, LRNG and NowComment. The content of multiliteracy learning was delivered to the residents in a process that asked them to learn in multimodal ways as they learned more about how LRNG playlists work and about annotating in NowComment. Once the residents completed activities on LRNG and NowComment, they were given feedback by professors in the LUTE-STEM program and by teachers in the New York City Writing Project. This team grew to know and value each other's contributions both in the process of creating the playlists and in the assessment and awarding of badges to the residents.

To open the second playlist, the residents had to earn the badge for the first playlist. Then they were able to open the longer, more in-depth playlist, *Multimodal Literacy: How Students Acquire Knowledge in Your Discipline.* In this playlist, which was central to the online, asynchronous experience designed for the LUTE-STEM residents in the summer prior to the residency year, participants were asked to think deeply about how to build on students' strengths as multimodal learners and to move them toward the learning goals of their specific STEM disciplines.

The playlist provides both the intellectual framework and a set of practical tools that candidates could use in their residencies and beyond. Having become familiar with NowComment in the previous playlist, here they received an invitation to use NowComment to explore, annotate, and discuss an array of selected texts on multiliteracies.

In this playlist, candidates were asked to complete the following:

- **Explore:** Use Pat Carini's prompts in the four categories of her *Description of a Child* (in Strieb et al., 2011) to describe a potential student in their discipline in ways that affirm their strengths as multimodal learners. They were also asked them to share this with other STEM teachers as a Field Note on NowComment.

- **Learn:** Annotate, analyze, and discuss texts, images, and videos that were selected. This helps the candidates expand their knowledge of the role that multiliteracies play in bridging what their students already know and can do and what those students will need to know and be able to do to be successful in the candidate's chosen discipline.
- **Apply:** Playtest examples of activities for learning in their discipline. Annotate these activities on NowComment. Reflect on their experiences as learners and consider the implications this has for teaching the youth who they were observing and describing in field notes.

Readers are provided with one resident's journey through the second playlist, *Multimodal Literacy: How Students Acquire Knowledge in Your Discipline,* and the work she did to earn a badge by meeting the following criteria (listed in the metadata for this badge):

- You will learn to build on students' strengths as multimodal learners to move them toward the learning goals of your discipline.
- You will sharpen your ability to describe students' strengths and how these might be connected to multimodal learning in your discipline.
- You will know how to gather facts, consider different opinions, and form your own ideas about questions you have about Multimodal Literacy.
- You will begin to see how multimodal literacy can help connect your students' strengths with the academic work of your discipline.

The resident in this case example is referred to as "A." For the first bullet point listed in the criteria above, A was asked to write a portrait of a student in her discipline:

Belle's interactions were very limited at school, but at home she was the center of attention and she was the one who had to take responsibilities of her siblings when the parents were too busy or not around. She loves her siblings as well as children, she relates easily with those younger than her, but she doesn't know how to interact with her peers. Belle still misses her friends back home; she finds that she has more in common with them than her peers here. She feels out of place. She has a great relationship with her parents, but also tends to avoid other adults. She has built a wall that only allowed those close to her to see and know what her personality is like.

The badge evaluator responded to A about her descriptive review:

This is a remarkably powerful portrait of an emergent bilingual learner who comes to the U.S. as a middle school student. Have you modeled Belle after someone you know? It is a good reminder that context matters, and that certain settings bring out the best in us while others do not.

For the second criteria bulleted above, A read and annotated a collection of articles, images, and videos about multimodal literacy through the lens of her own "burning question about a wicked problem" in her STEM discipline. After reading and replying to many of A's comments, the reviewer wrote the following comment:

There is a theme that runs across your annotations. You are committed to getting students to be independent learners. You are also committed to providing adolescents with an avenue to express their ideas and establish their own voice. I wonder if you might consider using Youth Voices with your students this year (with your host teacher's permission, of course).

The third criterion in this badge asked residents to work through problem sets and online curriculum from their disciplines. Once again, A used annotations to evaluate the problem sets, articles, and videos. Here, the evaluator appreciated A's thoughtful comments, and suggested what might be next for her work in understanding multimodal learning in mathematics:

You recognize, in your annotations on math problems, that children may struggle in math because of the academic language required rather than because of the underlying math concepts. How could you deconstruct the language so that children can get to the "core" of the problem?

A earned the badge after meeting all three criteria. In addition to submitting her own work, she was actively engaged with her peers as she added her voice to the dialogue that emerged on the NowComment site. Each resident was able to make choices as they navigated badge requirements that allowed for variation in subject area, intended grade level, and personal interests. A's work, focused heavily on English Learners, was uniquely hers. Other residents followed their own paths.

REINFORCING THE "STEM" IN LUTE-STEM WITH THE COMPUTER SCIENCE

Micro-Credential

Computational thinking (CT) across disciplines and grade levels is a signature aspect of LUTE-STEM. In order to reinforce the centrality of CT, LUTE-STEM leaders contracted with Mouse.org to create a computer science micro-credential. Coming up with a clear operational definition of CT that animates pedagogy and assessment discussions was the first step. Shute et al. (2017) provided an excellent point of departure. Their working definition, based on a review of the CT literature, emphasized an individual's ability to solve problems using algorithms (with or without computers) and arrive at solutions that can be applied to more than one situation, problem, or context. CT is also a mindset (much like Design Thinking) that can be broken down into the following subtopics: decomposition, abstraction, algorithm design, debugging, iteration, and generalization.

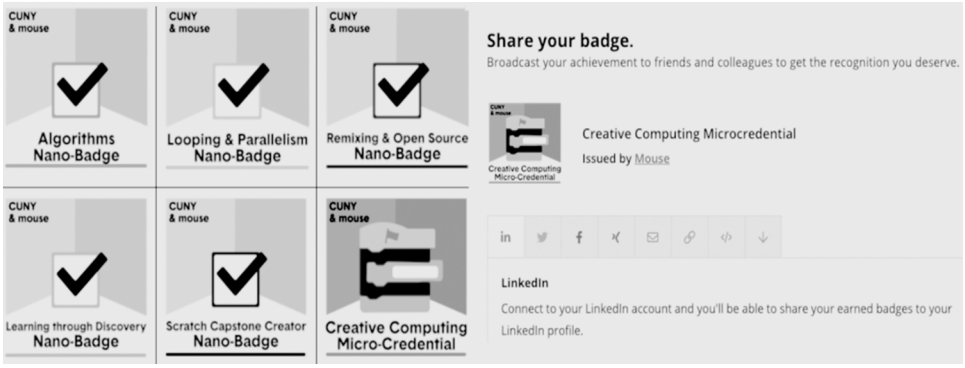
Residents were introduced to the micro-credential, *Creative Computing*, during Winter Session 2021. Hybrid delivery included one-hour Zoom sessions and asynchronous modules. The content of the micro-credential is a combination of proven computer science tools/concepts and curricula with innovative pedagogical lessons for classroom implementation. Technical skills are taught using Scratch, a programming language, and incorporating Harvard's *Creative Computing Curriculum* (Harvard Graduate School of Education, 2013). Although the curriculum was originally designed for K-12 students, it has been leveraged to allow residents to reflect on the creative experience from a student perspective while exploring the possibilities for cross-curricular implementation in classroom settings.

The micro-credential is split into five subtopics. Residents learn new skills in Scratch, then think about classroom applications. The implementation plans designed by residents can either use Scratch directly

or teach the same concepts in an "unplugged" setting. By combining the *Scratch Creative Computing Curriculum* with capstone pedagogical activities introduced at the end of each subtopic, we modeled for residents a way to guide their own students through lessons using what Resnick (2017) refers to as the "creative learning spiral" (pp. 10–14).

To provide adequate scaffolding and a feeling of achievement for the residents throughout the journey of earning the micro-credential, incremental badges deemed "nano-badges" were developed for the five subtopics of the course. The nano-badges, seen in Figure 1, represent a milestone in the resident's journey of earning the micro-credential. Each nano-badge is connected to a computational thinking concept the resident used to (1) create programs in the Scratch and (2) put into practice by designing a lesson plan that incorporates that skill across any subject. When the resident has earned each of the five nano-badges, they are awarded the Creative Computing Micro-Credential certifying their completion of the course and a key responsibility as a resident in the LUTE-STEM program.

Figure 1. Micro-credential Nano-Badges and Creative Computing Badge



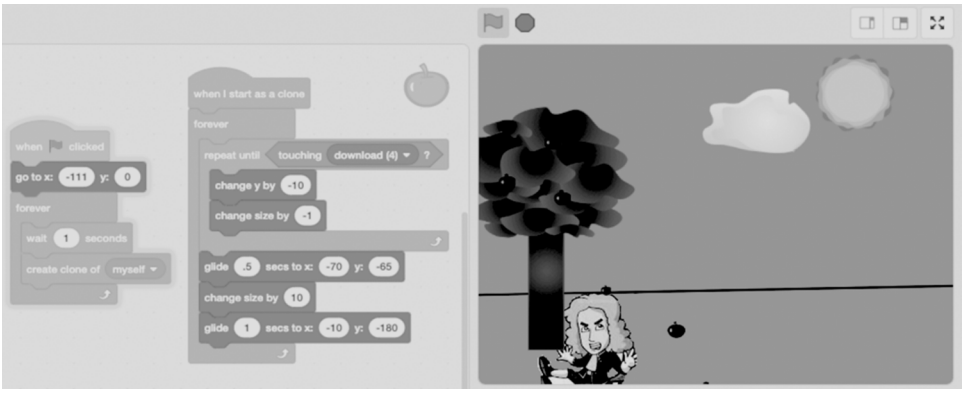
The nano-badges in this course were critical to the success of the program as they provided incremental success for the residents while also parsing out the five computational thinking subtopics below:

- **Algorithms:** A foundational computational thinking concept that is defined as a precise step-by-step set of instructions.
- **Looping & Parallelism:** Two separate yet related concepts in the LUTE-STEM course that consist of an action being repeated by one character of the program while another character is simultaneously carrying out a different task.
- **Remixing & Open Source:** A core component of the Scratch Programming environment in which users can freely share and copy each other's programs.
- **Learning Through Discovery:** A pedagogical approach to education in which students are tasked to be creators through play and interaction with a program instead of receivers of new knowledge (Resnick, 2017).
- **Scratch Capstone Creator:** In this subtopic, residents are tasked with designing a capstone project for their students that encompasses all the computation thinking skills earned in previous nano-badges.

In completing the tasks assigned on the way to earning their micro-credential, the residents demonstrated not only an understanding of concepts and routines but also an ability to apply what they have learned in different contexts. Readers are provided two illustrative work samples: one submitted by a secondary science resident and the second by an early childhood resident.

The science resident decided to create a visual representation of apples falling on Sir Isaac Newton's head as a humorous and engaging way to introduce the topic of gravity. To design and code this program, the resident was tasked with creating a Scratch program that utilizes the advanced concept of cloning. Cloning in Scratch is the feature that allows a character, often referred to as a sprite, to create a copy of itself while the program is running (Scratch Wiki, 2021). This resident demonstrated their ability to apply the computer science procedure with 100% accuracy by creating clones of the apple sprite so they will forever drop on Newton's head. The activity illustrated a wonderful piece of folklore from the history of science while modeling a computer science procedure that students could replicate (see Figure 2). The resident's activity made subject matter come alive and integrated computational thinking into the science classroom.

Figure 2. "Newton" program created by a spring 2021 resident in the CS micro-credential course



The second example demonstrates how an early childhood resident introduced kindergarteners to the notion of an open source. The term "open source" is used to describe software that is publicly accessible and developed collaboratively. The notion of an open source can be taught through other means than software; illustrative examples range from baking a cake to working on a physical object (National Science and Media Museum, 2012). In "Our Pinball Machine" lesson, the early childhood resident focused on a 30-minute activity that tasks design teams of kindergarteners with charting how to make a do-it-yourself pinball machine. The activity is aligned to *New York State Next Generation ELA Standards* (New York State Department of Education, 2017) and configured for a remote learning setting.

The residents, who at the outset were motivated by the Creative Computing Micro-Credential because it was tied to program requirements, became intrinsically motivated as soon as they earned the first nano-badge. These nano-badges provided tangible validation of progress towards the final goal. The assignments the residents completed on the Mouse Create LMS platform (create.mouse.org) connected to the badging platform Credly (credly.com) where the nano-badges sit alongside the micro-credential as evidence of residents' achievements. In this way, residents, the instructor, and college staff can con-

firm each resident's participation in a simple and public-facing manner that can be shared with a wider community.

CONCLUSION

What makes LUTE-STEM micro-credential content so compelling is that it disrupts conventional wisdom about what gets taught and by whom. The intent is to expand standard approaches to literacy and computer science instruction and emphasize interdisciplinary teaching and learning. Literacy does not "belong" to English/Language Arts teachers. In fact, by emphasizing multimodal literacy, LUTE-STEM encourages residents to think beyond reading and writing as ways to help students enhance their communication skills.

Similarly, Computer Science and the Scratch Programming language should not be siloed, relegated to a single teacher's responsibility. This micro-credential is a part of a greater movement to integrate computational thinking into other core subjects. Bringing together the concept of creative computing with specific pedagogical approaches and packaging these ideas into a micro-credential has shifted the way residents in Lehman College's LUTE-STEM program view the field of Computer Science while they practice applications of Computational Thinking across subject areas and grade levels. Initial survey reports from the course show that residents self-reported a greater understanding of the importance of computational thinking across the curriculum as a method to reach all students equitably. All residents who responded to open-ended survey questions noted the importance of CS and CT content for their students. Presentation of the course was rated particularly well—5.5 out of 6—which can be attributed, in part, to the scaffolding the nano-badges provided as resident earned their way to the micro-credential.

The introduction of micro-credentialing into Lehman College's teacher residency program has allowed pre-service candidates to immerse themselves in core principles of multimodal literacy and computational thinking in a manner that is both digestible and powerful. Both competency-based micro-credentials, designed specifically for LUTE-STEM pre-service residents, provide participants with practical skills that can be adapted across the curriculum so that the content does not just become inert knowledge. What is learned in these non-credit workshops becomes tools for implementation.

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REFERENCES

Aflatoony, L., & Wakkary, R. (2015, June). *Thoughtful thinkers: Secondary schoolers' learning about design thinking* [Paper presentation]. LEARNxDESIGN Conference. https://www.researchgate.net/publication/278027751_Thoughtful_Thinkers_Secondary_Schoolers%27_Learning_about_Design_Thinking

Androutsos, A., & Brinia, V. (2019). Developing and piloting a pedagogy for teaching innovation, collaboration, and co-creation in secondary education based on design thinking, digital transformation, and entrepreneurship. *Education Sciences, 9*(2), 113. doi:10.3390/educsci9020113

Azar, T., Hines, E., & Scheib, C. (2020). *Teacher residencies as a vehicle to recruit teachers of color*. National Center for Teacher Residencies. https://nctresidencies.org/resource/teacher-residencies-as-a-vehicle-to-recruit-teachers-of-color/

Bartz, D. E., & Kritsonis, W. A. (2019). Micro-credentialing and the individualized professional development approach to learning for teachers. *National Forum Teacher Education Journal, 29*(3), 1–11. http://www.nationalforum.com/Electronic%20Journal%20Volumes/Bartz,%20David%20E.%20Micro-credentialing%20and%20the%20Individual%20NFTEJ%20V29%20N3%202019.pdf

Carroll, M., Goldman, S., Britos, L., Koh, J., Royalty, A., & Hornstein, M. (2010). Destination, imagination, and the fires within: Design thinking in a middle school classroom. *International Journal of Art & Design Education*, *29*(1), 37–53. doi:10.1111/j.1476-8070.2010.01632.x

Clements, K., West, R. E., & Hunsaker, E. (2020). Getting started with open badges and open micro-credentials. *The International Review of Research in Open and Distributed Learning*, *21*(1), 154–172. doi:10.19173/irrodl.v21i1.4529

DeMonte, J. (2017). *Microcredentials for teachers: What three early adopter states have learned so far*. American Institutes for Research. https://www.air.org/sites/default/files/downloads/report/Micro-Creditials-for-Teachers-September-2017.pdf

French, D., & Barnett, B. (2017). Teachers, micro-credentials, and the performance assessment movement. *Voices in Urban Education*, *46*, 37–43. https://files.eric.ed.gov/fulltext/EJ1148462.pdf

Guha, R., Hyler, M. E., & Darling-Hammond, L. (2016). *The teacher residency: An innovative model for preparing teachers*. Learning Policy Institute. https://learningpolicyinstitute.org/sites/default/files/product-files/Teacher_Residency_Innovative_Model_Preparing_Teachers_REPORT.pdf

Hammerness, P., Williamson, K., & Kosnick, C. (2016). Urban teacher residencies. *Urban Education, 51*(10). doi:10.1177/0042085915618723

Harvard Graduate School of Education. (2013). *Creative computing curriculum*. Creative Computing Lab. https://creativecomputing.gse.harvard.edu/guide/index.html

Kohl, A. (2019). *Establishing a program for teacher micro-credentials to support individual professional learning* [Doctoral Dissertation]. Digital Commons@NLU. https://digitalcommons.nl.edu/diss/384/

Luka, I. (2014). Design thinking in pedagogy. *Journal of Education Culture and Society*, *2*(2), 63–74. doi:10.15503/jecs20142.63.74

Luke, C., & Young, V. (2020). *Integrating micro-credentials into professional learning: Lessons from five districts*. Digital Promise. https://digitalpromise.dspacedirect.org/handle/20.500.12265/103

National Center for Educational Evaluation and Regional Assistance. (2014). *Teaching residency programs: A multisite look at a new model to prepare teachers for high-need schools* (NCEE 2015-4002). U.S. Department of Education, Institute of Education Sciences. https://ies.ed.gov/ncee/pubs/20154002/pdf/20154002.pdf

National Center for Educational Evaluation and Regional Assistance. (2015). *New findings on the retention of novice teachers from teaching residency programs* (NCEE2015-4015). U.S. Department of Education, Institute of Education Sciences. https://ies.ed.gov/ncee/pubs/20154015/pdf/20154015.pdf

National Education Association. (n.d.). *Microcredentials*. https://www.nea.org/professional-excellence/professional-learning/micro-credentials

National Science and Media Museum. (2012, March 27). *Animation explaining open source culture* [Video]. Youtube. https://www.youtube.com/watch?v=gobBQwtFeyk&lc=UggnhWaaXX0k1ngCoAEC

Noel, L., & Liub, T. (2017). Using design thinking to create a new education paradigm for elementary level children for higher student engagement and success. *Design and Technology Education: An International Journal, 22*(1), 1360–1431. https://ojs.lboro.ac.uk/DATE/article/view/2198

Paull, Z., DeMoss, K., & Mansukhani, D. (2021). *Aspiring for more: deeper partnerships for sustainable residencies*. Prepared to Teach, Bank Street College of Education. https://educate.bankstreet.edu/cgi/viewcontent.cgi?article=1008&context=pt

Pusey, S. (2019). *How micro-credentials can encourage professional development among teachers*. EDSCOOP. https://edscoop.com/how-micro-credentials-can-encourage-professional-development-among-teachers/

Razzouk, R., & Shute, V. (2012). What is design thinking and why is it important? *Review of Educational Research*, *82*(3), 330–348. doi:10.3102/0034654312457429

Resnick, M. (2017). *Lifelong kindergarten: cultivating creativity through projects, passion, peers, and play*. MIT Press. doi:10.7551/mitpress/11017.001.0001

Scratch Wiki. (2021, February 12). *Cloning*. https://en.scratch-wiki.info/wiki/Cloning

Shute, V., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review*, *22*, 142–158. doi:10.1016/j.edurev.2017.09.003

Strieb, L., Carini, P., Kanevsky, R., & Wice, B. (2011). *Prospect's descriptive processes: The child, the art of teaching, and the classroom and the school – Revised.* Prospect Archives and Center for Education and Research. https://cdi.uvm.edu/sites/default/files/ProspectDescriptiveProcessesRevEd.pdf

West-Puckett, S. (2016). Making classroom writing assessment more visible, equitable, and portable through digital badging. *College English*, *79*(2), 127–151. https://library.ncte.org/journals/ce/issues/v79-2/28810

Zeiser, K., Taylor, J., Rickles, J., Garet, M. S., & Segeritz, M. (2014). *Findings from the study of deeper learning: Evidence of deeper learning outcomes*. American Institutes for Research. https://www.air.org/sites/default/files/downloads/report/Report_3_Evidence_of_Deeper_Learning_Outcomes.pdf

KEY TERMS AND DEFINITIONS

Computational Thinking: Problem-solving using algorithms with or without computers.

Design Thinking: A series of problem-solving steps that focus on empathy, teamwork, innovation, and consideration of multiple perspectives.

Interdisciplinary STEM Teaching: Integration of computer science and literacy practices in science and mathematics classrooms.

Multi-Modal Literacy: Forms of communication that combine two or more modes of expression (linguistic, visual, aural, spatial, and/or gestural).

Nano-Badges: Incremental badges that serve as milestones in the sequence leading up to a micro-credential.

Playlist: A description of activities that must be completed in order to demonstrate competency.

Teacher Residency: Field-based teacher preparation that incorporates a year-long clinical experience.