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Exploring Capstones as an Indicator of Postsecondary and Workforce Readiness:

A Descriptive Case Study of Capstone Experiences at Two High Schools

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Introduction

After the trending wave of pandemic-induced test-optional college admissions policies (Camara & Mattern, 2022) coupled with numerous controversies and cheating scandals surrounding college entrance exams (Zwick, 2022), more than 1,800 colleges and universities in the United States declared that they would no longer require applicants to submit SAT or ACT test scores in 2021. Not only was it becoming clear that these tests were gameable or coachable (Toppo, 2020; Messick, 2009), but questions also surfaced around whether the test content and format can result in true, equitable representations of students' college readiness skills (Aguinis, Culpepper, & Pierce, 2016; Zwick, 2022). These questions have led to an increased interest from institutions of higher education and K-12 to consider supplementary and alternative ways to evaluate postsecondary and workforce readiness (PWR) knowledge and skills beyond SAT and ACT testing.

This growing interest in K-12 education to evaluate PWR knowledge and skills more comprehensively beyond test scores was inspired by the reality of a transforming global labor market that the World Economic Forum refers to as the Fourth Industrial Revolution (World Economic Forum, 2016). A confluence of changes in the ways of working and rapid technological advances now compels the job market to seek employees with certain *essential* or 21st century skills that include creativity, collaboration, complex problem solving, adaptability, and cognitive flexibility, as well as basic proficiencies in mathematical reasoning, reading and writing skills, and technological dexterity (Tsekeris, 2019; World Economic Forum, 2016). With such radical shifts taking place in the labor market, what can schools do to ensure that they are rigorously preparing students for these shifts?

An increasingly popular alternative supported by states to evaluate PWR is a capstone experience or project. Buzzetto-More (2013) describes capstones as experiences that require students to "apply higher-order thinking, authentic learning, and multilayered decision-making while engaged in an experiential learning activity" (p. 81). Several states have adopted capstone experiences as part of their graduation requirements. For example, districts in the state of Colorado use a "Menu of College and Career-Ready Demonstrations" (henceforth referred to as the "menu of options") for students to meet graduation requirements and demonstrate PWR, which includes achieving certain scores on the SAT or ACT, the completion of a district-level designed capstone course, completion of a standards-based performance assessment, as well as other options (CDE, 2021a). Similarly, in other states, such as North Carolina or Tennessee, capstones are not required but can be pursued as a requirement for graduation by districts through which students complete a project or an experience that demonstrates mastery of a set of PWR skills (Kannapel, 2012).

We define capstones as experiences designed to give students autonomy and structure to meaningfully engage in an "extended process of inquiry in response to a complex question, problem, or challenge" (Buzzetto-More, 2013, pg. 81). While the schools we analyze in this paper have constructed a capstone course to support students in completing a capstone project, the range of possible capstone experiences is wide and diverse. Capstones can take the form of self-directed culminating projects, projects structured to be developed over an extended period of time (e.g. a semester, a school year, or over several school years), projects developed within a course designed to support the capstone development, internships with a required capstone project submission, the development and presentation of a portfolio of various learning artifacts collected over a period of time, and much more. The connection across diverse capstone forms is that these experiences, however they take shape, should

enable students to demonstrate content mastery and 21st century skills through the application of skills such as planning, critically analyzing information, and collaborating with peers over an extended period of time (Speckels, 2011; O'Grady, 1999). When capstones are designed well, a student's final product could represent a sufficiently rigorous demonstration of a student's development of 21st century skills (referred to as "essential skills" in Colorado) and mastery of high school level mathematics, reading, and writing competencies. Well-designed capstones would also embed high-quality performance-based assessments (PBAs) to assess student performance on assigned tasks and on the final learning demonstration required by the project to establish evidence of competency.

In practice, however, a range of interpretations and applications of capstones can be observed across the country with designs that vary widely from being purely skills and career focused, to being intentionally designed to ensure students demonstrate specific skills and mastery over content to meet graduation requirements, such as seen under the Rhode Island Diploma System (Rhode Island Department of Education, 2018). This open interpretation and application are driven in large part by how local districts interpret and define capstone requirements for their students. For example, in Colorado, the Colorado Department of Education (CDE) suggests guidelines for capstones, but the state has no authority to define expectations for or to assure the quality of capstones provided to students. Thus, the onus falls on districts to develop capstone requirements that can meet rigorous graduation requirements. The lack of capstone policy expectations set in states such as Colorado, Tennessee, or North Carolina, guarantees that districts and schools within those regions are likely to have varying expectations set for assessing student competency on these types of courses and culminating projects.

In this paper, we present results from an exploratory descriptive case study (Mariano,1993; Yin, 2014) sponsored by CDE to learn about the extent to which two Colorado high schools at the early stages of piloting capstones with their juniors and seniors could effectively evaluate PWR knowledge and skills. Due to the growing interest across districts to embed PBAs into their capstone processes, CDE was particularly interested to learn how PWR could be evaluated through capstone processes involving performance assessment. We adopted this case study approach since limited research and documentation exists in Colorado to understand how capstone experiences are enacted in classrooms. These two schools were selected by our partners at CDE because these represented schools at the beginning stages of designing and trying out capstones with embedded PBAs. In addition to wanting to learn how these schools would address content demands while fostering 21st century or essential skills in the activities and performance assessments designed for these courses, CDE also wanted to learn about the challenges experienced by sites testing out the capstone experiences. At these two schools, the capstone designers planned to use PBAs in capstones to help establish evidence of academic competency demonstrations in English Language Arts (ELA) and Math.

For this case study work, we examined capstone lesson plans and rubrics, conducted classroom observations of capstones, and interviewed teachers and state level officials, to consider how the capstone experiences designed and offered at two separate schools: 1) provide students with opportunities to drive their learning and to explore project options in substantive ways; and, 2) hold potential for meeting the aspirations for capstones and PBAs as defined by the Colorado Department of Education in the graduation guidelines.

In this paper, the first section presents background context and information on graduation requirements in the State of Colorado and how this motivated the inclusion of capstones and PBAs as part of state Graduation Guidelines. The second section discusses literature on high-quality capstones in secondary and postsecondary institutions. The third section presents findings from two Colorado high schools as it relates to their design and implementation of PBA-embedded capstones. The fourth section discusses the implications of these findings for expanded use of PBA-embedded capstones as an alternative, rigorous pathway for demonstrating PWR skills and as they relate to larger instructional infrastructure challenges. We conclude this paper by sharing a set of considerations to better support districts and schools seeking to establish capstones.

Background and Context: CDE Guidance around Capstone, PBAs, and Graduation

State interest in offering capstones originated from Colorado industry demands for consistency across high school graduate skills and capacity. Prior to the 2008 recession, companies were facing a labor shortage as the skills of employees began to lag behind the increasing skill demands of employers. According to an interviewed CDE staff member, when attempting to hire Colorado high school graduates, companies noted inconsistencies in the capacities of recent graduates from different parts of the state, which compelled industry leaders to approach the state legislature to call for a standardization of the skills that students are expected to have mastered by graduation.

In response to these demands, legislation passed in 2009 that led the Colorado State Board of Education to adopt the Graduation Guidelines to help inform district choices on how students can demonstrate competency of PWR skills. To elaborate the Graduation Guidelines, seven workgroups met over the years with educational experts across the state to establish a menu of options for demonstrating college and career readiness upon graduation. A key defining feature of these guidelines was that the choice and implementation of menu options are entirely determined by the district on a student-by-student basis.

Although the legislation left considerable room for districts to interpret graduation requirements, the state published a menu of options that districts currently use to guide graduation policies. This menu of options outlines a range of pathways for students to demonstrate College and Career Readiness which includes achieving certain test scores on the SAT or ACT or successfully passing Advanced Placement (AP) or International Baccalaureate (IB) exams, as well as the completion of capstone processes and collaboratively developed performance-based assessments. Initially, the menu of options included the subject areas of reading, math, science, and social studies. However, due to limitations in being able to identify various assessments that measure performance across all subject areas, the workgroup decided to only include language requiring students to meet predetermined criteria on at least one measure in Reading, Writing and Communicating (RWC), and one measure in Math. While the graduation guidelines expect students to demonstrate proficiency in these content areas in ways aligned with Colorado Academic Standards, the RWC and Math expectations under each menu option vary. For example, the Reading, Writing, Communicating, and Math expectations for district capstones are “individualized” to the student, suggesting that academic learning demonstrations

can be determined collaboratively by the student and teacher in line with district guidelines. Whereas the expectations for collaboratively developed performance-based assessments require students to meet expectations under a predetermined, state-wide scoring criteria for both RWC and Math.

To obtain a better understanding of the history and guidance around capstones, PBAs, and Graduation Guidelines, we interviewed the CDE Graduation Guidelines Manager and reviewed publicly available graduation guideline documents located on CDE's website. During this interview, we discussed the history of the Graduation Guidelines, CDE's authority over enforcing Graduation Guidelines, capstones, and PBA implementation, as well as how CDE aims to support and monitor schools in addressing Graduation Guidelines. Below we unpack insights gleaned from the interview and from our document review to provide context for the capstone work pursued by the high schools focused on in this paper.

CDE Capstone Guidance

To outline guidance around capstone processes, the state workgroup responsible for developing Graduation Guidelines established a capstone work group. In 2014, CDE published the capstone work group's "Portfolio and Capstone Guidebook", which explains the multiple pathways and approaches that districts can take in designing and implementing capstones (CDE, 2014). CDE defines capstones as "a multifaceted body of work that is district determined and serves as a culminating academic and intellectual experience for students (CDE, 2022a)." For districts interested in offering capstones as an option for students to demonstrate college and career readiness, districts can opt to design a course that scaffolds students into completing a project. Student work can also be collected over a period of time in particular subject areas to include in a culminating portfolio of learning. In fact, the guidebook names a multitude of capstone design pathways, including a portfolio defense, research exhibition, a scientific experiment, a service-learning project, or even an event coordination experience. It also notes that schools may use capstones to achieve different objectives, such as assisting students in exploring post-secondary opportunities or to measure 21st century skills, local priorities, academic achievement in or a combination of all of these criteria (CDE, 2014). This general guidance encompasses a wide range of design approaches and gives districts autonomy to decide which design approach is best suited for their students.

CDE emphasizes the authority districts have in determining policies and requirements for capstone processes. The state's influence on capstone design is limited to providing examples of capstone experiences across the state and to hosting town hall meetings to provide districts the opportunity to learn from other districts implementing capstones. However, beyond this limited role, the state ultimately does not have any authority to specify design expectations for capstones nor evaluate whether the district's approach aligns with recommendations outlined in the CDE capstone guidebook. Therefore, the structure and quality of the capstones can vary widely across districts and even across schools or classrooms, depending on the guidance districts provide to their schools.

As several districts have recently begun to experiment with offering capstones, schools have taken up this work in a number of ways to meet various local needs. The CDE manager explained that districts can elect to design the capstones to focus on subject area content or areas outside of academics. According to the manager, many districts that offer capstones choose to implement a primarily skills-driven approach to the design of capstone experiences. These "skills-driven" capstones can consist of student-led projects or experiences that focus more on student

skill development in areas like community service or project building rather than academic content mastery. However, the CDE manager also noted that some districts do elect to develop capstones that address both academic and essential skill development. For this reason, the capstone experiences are likely to vary widely across the state, which means that expectations established across schools would likely also vary widely for meeting graduation requirements.

CDE PBA Guidance

In contrast to the general CDE recommendations set for capstones, the guidance provided by CDE on the collaboratively-developed performance based assessment menu option encourages districts to engage students in an "authentic demonstration of student knowledge and skills through the creation of a complex product or presentation (CDE, 2022b)." Here, the state guidance explicitly calls upon the inclusion of state standards in this demonstration of college and career readiness. Under this option, the state envisions students developing a product or presentation that specifically demonstrates mastery of state academic standards as well as what CDE refers to as essential skills, which include skills like communication, problem solving, civic engagement, and much more. CDE envisions PBAs being used to meet graduation requirements by embedding these assessments in English Language Arts (ELA) and Math in ways that would require students to build content mastery while drawing on essential skills to complete a product or presentation. The collaborative nature of these assessments lies in the way the tasks and rubrics are intended to be developed through teacher professional learning communities (PLCs). Ideally, teachers would collaborate to develop curriculum-embedded tasks that scaffold students into completing a PBA over time. This collaboration can also extend beyond teachers and move into working with students to co-create success criteria used in rubrics and develop task objectives.

Since any district that offers PBAs as an option for students to meet graduation requirements must require students to demonstrate mastery of RWC and Math using state-wide scoring criteria, the state has provided clearer expectations around how these PBAs should be designed and implemented. To support this PBA effort, CDE partnered with a teacher training firm, called 2Revolutions, to establish a state-wide PLC and also provide training to teachers across the state on how to design and implement PBAs. CDE also partnered with the Center for Assessment, Design, Research, and Evaluation (CADRE) at the University of Colorado-Boulder to document how schools that claim to employ PBAs in core subject areas or capstones use these assessments to evaluate student learning.

Although districts within this local control state have largely steered the design of capstone experiences, there is growing interest expressed by schools and districts in using the state-defined PBAs for graduation requirements and integrating these into capstones. According to CDE, districts have expressed excitement around using PBAs and some, such as our two case study sites, already claim to be using them in their capstones. For sites that are planning to or have integrated these two distinct options, this integration may provide an opportunity for students to experience more academic capstones that guide students into demonstrating content mastery and PWR skills. That is, these experiences may potentially provide guidance for the general capstone process as well as a plausible alternative in the future to evaluate content-specific competency in place of a standardized test.

CDE Graduation Guideline Guardrails

Despite the provision of comprehensive academic state standards, the state's course *requirements* for high school graduation remain limited. According to the 2021 legislation, only one semester of civics and one course on Genocide & Holocaust Studies are required

for high school students by state law. Other than the completion of these two courses, the state does not *require* students to complete any other credits before graduating high school. To more concretely guide course credit requirements, most districts use higher education requirements to guide their list of required credits for graduation. Prior to 2018, all Colorado districts designed their high school course credit requirements to be in line with the Colorado Public Higher Education Admission Requirements (HEAR). After 2018, the HEAR became *recommendations* rather than requirements. Despite this switch, all but one Colorado district maintained course credit requirements that were in line with the HEAR. In most districts, students must meet some combination of credit requirements and Graduation Guidelines to graduate with a high school diploma.

CDE does not prescribe which menu option districts offer to their students, and all districts are expected to incorporate the CDE Graduation Guidelines into their local school board policy. Districts must identify at least one measure in RWC and one measure in Mathematics from the menu of options that they will use to evaluate whether students demonstrate college and career readiness. To support districts in meeting this requirement and to satisfy federal testing requirements, every student takes the SAT for free in 11th grade. However, the CDE manager noted that SAT can often be an insufficient pathway for many students to adequately demonstrate college and career readiness in the state of Colorado, as this test does not comprehensively evaluate essential skills (e.g., self-regulation, collaboration, and personal responsibility) nor can this evaluate the RWC standard focused on oral communication. Therefore, districts have the opportunity to turn to other menu options for their students to more broadly demonstrate PWR content acquisition and essential skills.

Regardless of options selected, CDE does not have the authority to challenge the quality of other measures (i.e., such as capstone, industry certifications, and PBAs) used to evaluate PWR. Because there are no periodic audits or reviews of these other outcomes and processes designed by schools or districts, no evidence has been collected to date to understand whether alternative approaches deployed at different districts provide adequate and rigorous evaluations of PWR. At present, the scrutiny of whether students are adequately prepared for PWR largely informally rests on the institutions receiving graduates as students or employees. However, it is important to note that the 2021-22 school year marks the first year that the full suite of menu options is officially in place. Given that this is the first year of officially launching the Graduation Guidelines, these early implementation years offer great potential to learn from this emerging body of work taking place across the state.

The CDE manager explained that districts must be able to defend the rigor of their own graduation requirements to their local board, parents and even students. Since the 2021-22 school year marks the first year of implementing the new Graduation Guidelines, CDE anticipates that community stakeholders may request districts to provide more detailed information to learn what is expected of students in capstones versus what is expected of students who, for example, take the SAT or complete IB and AP exams to demonstrate college and career readiness.

While CDE may not be able to intervene in district processes for meeting the Graduation Guidelines, it is committed to ensuring these options exist and are made available to their students. As the debate continues in Colorado and nationally about whether standardized tests like SAT, ACT, IB or AP exams, can serve as sufficient measures of PWR (Darling-Hammond, Wilhoit, & Pittenger, 2014), CDE is

compelled to offer multiple pathways for students to demonstrate PWR more holistically. In an effort to address best practices and innovations in the learning sciences that point to project-based learning and performance-based assessment as having potential to foster deeper learning and equitable assessment practices (Krajcik & Blumenfeld, 2006; Fine & Pryiomka, 2020), CDE is also committed to ensuring that all students receive opportunities to show what they know and can do in ways that are also authentic and rigorous. These considerations have led to the addition of collaboratively developed PBAs to the menu of options and motivated interest in some places, such as our case study sites, to find ways to integrate PBAs into capstone experiences to ensure both academic content knowledge and skills, and essentials skills can be addressed by capstones.

However, despite the excitement around the collaboratively-developed PBA and its potential for bringing more rigor into capstones, there are natural tensions between these two graduation guideline menu options given the contrasting nature of how students are expected to demonstrate PWR skills under these two CDE pathways. To discuss the ideal for capstone design and implementation, we now move to the next section which presents the literature on developing high-quality capstone experiences and their inherent connection to PBAs.

Literature on High-Quality Capstone Experiences

Given the relatively new emergence of capstones in the educational landscape (with first discussions of capstones dating back to the late 1980s and early 1990s, see Bowman, 1989 and Wheatley, Roberts, & Einbecker, 1990), the literature on best practices in designing and implementing high school capstones is limited (Kannapel, 2012). Much of the literature on capstone projects discusses these experiences in the context of undergraduate and graduate coursework rather than in high school settings (Hammer et al., 2018; Dugan, 2011). Yet, the literature that does exist affirms similar notions around developing high-quality capstone experiences, whether for high school or college students. When discussing capstone design, Kannapel (2012) notes that the literature consistently emphasizes key features of this experience which include student-centered design, fostering higher order thinking skills and problem solving, cross-curricular elements, collaborative group work, teachers serving as advisors and community members serving as mentors, and a final presentation before a panel of judges (p.3). These features are essential for enabling students to drive their learning, draw connections between the content they have learned across subject areas and how it relates to the real-world, and develop skills that are important for college and career success (Lai, 2012, Wathington et al., 2012). Below, we discuss the importance of these various components in designing a high-quality capstone experience.

Authentic, Student-Centered Design

Perhaps the most important and distinguishing feature of capstones is its focus on students comprehensively demonstrating mastery of academic concepts within the context of a project directly related to their interests (Buzzetto-More, 2013). The learning process towards completion of a capstone is entirely student-driven. While structures are provided to students to support and guide them in completing their capstone (Chang, 2019), project objectives, milestones, and rubrics can be collaboratively developed by students and teachers (Johari, 2017). Under a high-quality capstone, students identify authentic applications of academic content through considering issues or problems relevant to their daily lives, community, or anticipated careers (Chang,

2019). Once a question or problem is posed, students become responsible for identifying an answer or solution based on the deep research and experience they develop as a part of the capstone project. Note that features of high-quality capstones align with features of high-quality project-based learning (Baines et al., 2021), and are in fact interchangeable. Students are no longer expected to present a right or wrong answer but rather must demonstrate deep understanding of how various academic concepts relate and support the identification of solutions to a practical, real-world issue (Chin et al., 2011). Giving students the opportunity to choose their own project topic and work within the provided structures to determine project objectives enables students to feel more autonomous and engaged in the capstone process, which can lead students to have deeper learning experiences and higher levels of motivation (Evans & Boucher, 2015).

Equity-Oriented Approach

While authentic, student-centered design may be central to harnessing the benefits of a capstone process, high-quality capstones cannot be genuinely achieved for all students without an equity-oriented approach to the design and implementation of the capstone experience (Adams & Duncan Grand, 2019). Planning the capstone process requires paying careful attention to equity to effectively develop project tasks and activities that "… are relevant and connected to students' lived experiences, culture, and language, and encourage multiple pathways to learning (Haydel et al., 2017, p.145). All students should be seen as capable of producing high-quality work outcomes and should be supported to meet high expectations. Learning spaces should be free and clear of identity stereotypes or deficit perspectives, as these can harm student motivation and self-efficacy (Hernandez et al., 2019). Given that capstones encourage students to take risks by pushing the learning boundaries, teachers must build relationships with students and foster a learning environment where all students feel welcomed, safe, and supported to explore and make mistakes as they develop their final demonstration of learning. Teachers should aim to make the capstone process directly connected to the everyday lived experiences of students, which may require an active confrontation of social justice topics or current events that push students to think critically about the purpose, design, and implementation of their capstone (Randall, 2021).

Cognitively Demanding Expectations

Capstone projects possess great potential for students to rigorously demonstrate mastery of various academic skills in the context of a project they design to answer a question of personal interest (Buzzetto-More, 2013). When done well, capstones support students in building deep knowledge around academic content in ways that are relevant and authentic, and in essence reflect project-based learning (PBL) or inquiry-based learning (IBL) (Ford & Lasher, 2004; Suarez et al., 2018; Johari, 2017). For example, Baines et al (2021) define rigorous PBL as "...authentic, meaningful, and coherently designed project experiences [that] are central to deep and comprehensive content understanding (p. 2)." Friesen & Scott (2013) further support this point in the context of IBL, highlighting that although IBL engages students in challenging tasks that require extensive research around a key question or problem, learning growth or deep academic learning demonstrations cannot be expected when IBL approaches are unstructured and not grounded in academic content (pp. 22-24). This literature underscores the importance of integrating academic expectations into capstone processes to ensure students are engaged in a rigorous, cognitively demanding, authentic experience. This becomes especially important when capstones are intended to serve as representations of high school level mastery of academic standards.

Additional salient features of rigorous capstones include metacognitive and self-regulating tasks that develop important habits of the mind (Harada, 2016; Buzzetto-More, 2013). Johari (2017) describes high-quality capstone experiences in Chelsea, Massachusetts that require students to reflect on learning and revise their project product ongoingly in response to their reflections on their process. She observed students using their capstone project rubrics, teacher feedback, and peer feedback to make sense of their performance and make changes accordingly throughout the school year. It is in this component of the project that researchers find community mentors playing particularly important roles in providing expertise-based feedback that helps students identify more practical solutions or develop stronger projects, gaining knowledge that allows "them to understand and operate in their future careers" (Pembridge & Paretti, 2011, p. 22.173.9). Johari (2017) notes that "the inclusion of reflection and revision as part of the [capstone] cycle adds rigor, allowing for a second, meta-cognitive level of learning (p. 45)." Teachers can support and structure this process for students by using the project rubric to guide students through evaluating whether their project is on track to meeting expectations, identify areas for improvement, and create plans to address the feedback (Harada, 2016; Johari, 2017). Students having the opportunity to iteratively reflect on their progress and redraft elements of their project over an extended period of time effectively scaffolds their capstone development and gives students the chance to master concepts more deeply to later demonstrate the full depth of their learning through the final capstone presentation (McNeill, 2011).

Fostering *Essential* or 21st Century Skills

High-quality capstone experiences are intentionally designed to foster 21st century skill learning or essential skills (Chang, 2019; CDE, 2021b). In the previous section, developing students' metacognitive skills was discussed as being important to ensure capstones are rigorous learning experiences for students. Fostering students' metacognitive skills are also relevant to the development of essential skills for postsecondary workforce readiness as well as other skills such as critical thinking, communication, problem solving, civic engagement, self-regulation, collaboration, among many others (Ford & Lasher, 2004; also see CDE, 2021b). The literature on capstones emphasizes development of 21st century skills as being inherent to a quality capstone experience. Through working with teachers to identify a project topic, managing the project completion, revising their work, and presenting their final project, students should be given a range of 21st century learning opportunities to strengthen their PWR skills (Henning, 2016; Buzzetto-More, 2013; Johari, 2017). In a presentation of a framework for quality capstone project, Hammer et al (2018) notes that "capstones can act as sites to assure student attainment of disciplinary mastery and higher order academic skills, employability skills, and graduate attributes (p.733)." While these opportunities can occur organically, there should be well-defined tasks and activities that target various essential skills to be sure that students practice developing these skills as part of the capstone experience (Zeid et al., 2011). It is important to highlight that the literature does not support grading these essential skills as part of a student's evaluation on the capstone project, but rather the focus is on "developing" and building those life serving skills through the tasks and activities. This distinction is important since evaluating these essential skills as part of a capstone "grade" can be difficult and highly susceptible to teacher bias (Feldman, 2019).

Teacher Practices

Structuring a high-quality capstone experience for students requires teachers to employ key practices, including the provision of clear project guidance structures, skill development instruction, and the use

of formative assessment practices to support learning. Considering that high-quality capstone projects often require students to conduct extensive research on their topics of interest, execute a project to its completion, and present project results to a panel, teachers must present opportunities for students to learn how to identify a topic and research question, effectively conduct research, organize a project, synthesize findings, complete the project, and properly prepare for the final presentation (Chin et al., 2011).

Research on best practices for quality capstone design highlight the salience of teachers' provision of sound structures and instruction as well as their use of formative assessment practices. In a study where researchers aimed to provide capstone professional development to high school teachers, Harada (2016) found that training teachers to instruct, model, and formatively assess student development of research skills was essential to promoting student curiosity around project topic identification and appropriately conducting research to answer the proposed research question. That is, formative assessment practices enacted gave teachers insights into areas students were struggling with, created opportunities for teachers to share feedback, and enabled students to benefit from peer feedback. Strong use of questioning techniques that push students beyond locating or recalling information, requiring them to explain or discuss how concepts are related throughout instructional components of lessons are also cited as a key use of formative assessment practices in fostering deeper mastery of necessary content and skills for capstone completion (Dunlap, 2005; Buchanan Hill, 2016). Eppes & Milanovic (2011) discuss the importance of providing structures for students to practice oral presentations and obtain feedback from instructors, peers, and even mentors on ways they can strengthen their presentation as a part of preparing students for success in the final capstone oral assessment. Tio et al (2014) emphasize the direct connection between teachers making students familiar with the rubrics and guidelines that will be used to evaluate student work and fair assessment practices that give students the tools and training they need to produce a strong capstone). When teachers provide structures for students to learn how to effectively execute vital aspects of the capstone and offer several, varied opportunities for students to receive feedback and revise their work, students are more capable and feel more confident to engage in a high-quality capstone development experience (Tio et al., 2014).

Connection to PBAs

Across the United States, PBAs serve as important evaluation tools for high school student capstone projects or courses (Guha et al., 2018). The features of rigorous PBAs parallel those required in designing high-quality capstone experiences. The topics reviewed above as being essential for capstones–the pursuit of authenticity, cognitive complexity, integration of academic content, and fostering skills that transfer across subjects and in the real world— are all central components of designing high-quality PBAs (Linn et al., 1991; Lai & Viering, 2012). The capstone teacher practices that involve intentionally designing structures and providing instruction that effectively scaffolds students' skill development, making students familiar and comfortable with task objectives and rubrics, and creating multiple opportunities for students to receive feedback on their progress are all important practices for employing curriculum embedded PBAs (Lai, 2012). When well-designed and well-implemented, capstones can serve as the ideal site for using curriculum-embedded PBAs that guide students into rigorous demonstrations of PWR.

Having highlighted key features of high-quality capstone experiences, we now turn to a presentation of results from our descriptive case study and interpret these findings in relation to this literature.

Capstones at Two High Schools

We conducted descriptive case studies in two high schools at the early stages of implementing capstones to document the promises, challenges, and identify potential needs in the field for schools seeking to meet graduation requirements through this pathway. Another motivating objective for this work was to address the interest of the participating schools and teachers to receive feedback on improving their capstone practices. The first high school, Ash Innovation High, is located in an urban-metro school district and serves a student body with about 25% of its students identified as economically disadvantaged and approximately 40% of its students identifying as belonging to various minoritized groups. The second high school, Cottonwood High, is located in a rural school district and serves a student body composed mainly of students of color who are eligible for free-and-reduced lunch (FRL) programs.

At both schools, the capstone experience was structured within a capstone course that supported students to complete a capstone project. For this study, we observed two separate capstone classes for each teacher, reviewed the lesson plans carried out in those classes, and other capstone documents and tools provided to students. For our observations, we used an observation protocol that focused on examining the extent to which teachers used a combination of formative assessment practices, essential skills, and authentic tasks to support the capstone experiences as recommended by the literature. We supplemented these "look-fors" with field notes taken during each observation. Following each observation, we carried out a debrief session with each teacher to discuss what we observed and to obtain additional insights from teachers on the activities pursued. At Ash, we observed a mid-career ELA teacher, who we will refer to as Ms. Ramos, and an early-career mathematics teacher, who we will refer to as Ms. Joseph, teach capstones that span grades 11-12. At Cottonwood, we observed a veteran English Language Arts (ELA) teacher, who we will refer to as Ms. Strauss, teach capstones for grades 11-12. It was particularly useful to observe the classrooms of Ms. Strauss and Ms. Ramos because these teachers serve as the capstone and performance-based assessment leads at their respective high schools. In the following section, we discuss the capstone course design pursued by both schools.

Capstone Course Design

The capstone process at Ash Innovation is a semester-long experience that serves a mixed group of 11th and 12th grade students. Ash Innovation identifies two high school academic standards in their capstone plan for students to meet through their projects: A RWC standard related to conducting a short and sustained research project and a math standard relating to interpreting and analyzing functions using different representations. Students are expected to complete a community service or career readiness project aligned with their interests and submit an accompanying research paper. Student demonstrations of knowledge connected to the two academic standards highlighted in the capstone plan need to be reflected in the research paper focused on the topic of the capstone project and the final presentation. Ms. Ramos designed the capstones to equip students with the skills they need to complete the research paper and plan their project as well as to engage in collaborative peer-feedback, and reflective activities.

Students at Ash Innovation receive several resources and guidelines intentionally designed to scaffold students through each stage of the capstone project. Since Ms. Ramos is Ms. Joseph's teacher-mentor for capstones, both teachers implement the same

capstone lesson plans. At Ash Innovation, students receive a capstone project flowchart that clearly outlines the objectives, milestones, and activities that students need to achieve in order to complete the capstone course. Students independently time manage their work using a planning map that requires them to identify dates for when they expect to complete each step under the milestone flowchart. Students receive additional planning tools and resources including a topic brainstorming and selection guide that encourages students to identify projects building on their interests, a guide to selecting a question informed by the CDE essential skills, a research paper writing template, as well as a project budget planning template. As part of capstone requirements, students complete field journals, conduct a literature review and collect data on their project topic to develop a project proposal. At Ash, teachers regularly structure peer feedback opportunities in the classroom activities. To help students learn how to give constructive feedback to one another on their projects, the teachers provide students with peer feedback protocols, guidelines, and tools.

At Cottonwood, the capstone process is a year-long class that serves a mixed group of 11th and 12th grade students. Their capstone plan for students states that "projects will be used to gauge proficiency in literacy (reading/writing) and math." Similar to Ash Innovation, the course is designed to have students complete a community service or career readiness project related to their interests as the final product and demonstration of PWR skills. In addition to being a year-long class, the capstone course at Cottonwood provides students with the option to either work with other students on a project or to pursue these projects independently. For all projects, students are required to identify a community mentor that could support them in completing their capstone project. According to Ms. Strauss, student demonstrations of math and ELA proficiency should be reflected in the research paper and final presentations. For the capstones this year, Ms. Strauss incorporated peer feedback structures for the first time to ensure that students can receive input from peers to help improve and complete their projects. The capstone calendar and plan shared with students outlined expected activities for the capstone work (e.g., students must confirm their mentors and visualize their final project in November), but did not contain any guidelines or clear requirements for designing the projects. That is, the criteria used to determine what elements needed to be addressed or included by each student in their project deliverables were not specified in any of the documents shared which would indicate that students would not be able to undertake any self-assessments of progress made relative to any success criteria established for capstones.

Findings

Given the nascent stage of this capstone work at both schools, our findings of the activities enacted in the observed classes should be viewed within the context of a process or formative evaluation intended to inform improvement over time. We intentionally selected specific classes for our observations where activities focused on having students present their projects to peers and engage in peer feedback sessions. We selected these classes in order to become familiarized with the array of projects presented by students and to also gain a good sense of the capstone expectations being communicated and internalized by students through the success criteria used by peers during the feedback sessions.

Ash Innovation

At Ash Innovation, student projects were well underway by the time we began observing classrooms. Although students were at varying stages of completing their projects, they all appeared to have selected a topic

and were aware of the steps and tools needed to meet course expectations. The lessons we observed focused on having students understand expectations for peer feedback, and then to participate in feedback sessions as a means to improve and reflect upon their projects. Although the two classes we observed for each teacher were scheduled one month apart, these classes used peer feedback as the primary interactive activity taking place between students. Since the two capstone teachers planned together, the capstone classes taught by both teachers reflected the same set of activities and goals for students.

In the classes of the lead teacher, Ms. Ramos, she provided explicit instructions to students on the process for providing peer feedback. She modeled the peer feedback process by role-playing with other students to demonstrate the type of probing questions and input that should be provided to push students to reflect on their progress. She also showed a video of students in her other classes engaging in meaningful peer feedback and asked students to highlight elements of the video that exemplified good practices when engaging in peer feedback. The build-up work conducted by Ms. Ramos to carry out the feedback activities led into having students identify the criteria for providing good peer feedback. She then used these criteria to develop and co-create success criteria for the feedback session with her students. The capstone literature identifies this practice of modeling peer feedback and then collaborating with students to determine success criteria as important strategies that teachers can use to support student internalization of task objectives and self-regulating project completion in capstones (Johari, 2017; Fraile, Panadero & Pardo, 2017; Tio et al., 2014). As a result of the build-up work, most of the individuals observed in the small groups of four to five students appeared to have a clear sense of how to engage in the peer feedback activity.

Ms. Joseph's class focused on the same goal as Ms. Ramos' class to establish peer feedback structures, but at a different pace. Ms. Joseph moved rapidly through the instructions for engaging in the peer feedback activity. She then showed the same peer-feedback video that Ms. Ramos used but fast-forwarded through most of the video without pausing to check for student understanding. She concluded her introduction to the feedback activity with a few statements about good peer feedback practices. Ms. Joseph then assigned students to large groups of ten students to engage in the activity. During the peer feedback sessions, students expressed confusion about what feedback should be given and due to the large size of the groups, they had very little time to effectively present and receive any feedback. Compared to her mentor's class, the pacing and minimal scaffolding provided in Ms. Joseph's class contributed to lower levels of task clarity and productivity among her students.

Friesen & Scott (2013) warn that capstone experiences are not likely to lead to deep, rigorous learning if they lack academic rigor and content. During the classes observed at Ash, there was great potential for academic rigor and content to be integrated in the capstone process. However, opportunities to discuss project connections to content and/or the requisite academic standards did not take place and the student-designed projects shared by students lacked content connections. During their project presentations to peers, students discussed logistical work associated with carrying out activities such as a bake sale, establishing a basketball training camp, setting up a home gym, developing a skin care video tutorial, and painting shoes. While the lessons and student conversations we observed did not make explicit connections to essential skills, there were several indicators that certain essential skills, such as interpersonal communication or collaboration/teamwork skills, were being organically fostered in the process. However, there were no data collection efforts undertaken by students to support many of the

projects. In some cases, such as the shoe painting project and the skin care video, the project designs lacked clear connections to PWR expectations or clear benefits to the community. Based on the details shared by students about the project work, we questioned the extent to which grade level math expectations outlined in the capstones' documentation could be met and also questioned whether some of the topics were being explored in enough depth to lead to any clear transfers of learning. Although students were given great latitude to pick and design their projects, we could not discern how grade level content expectations could be met through the activities planned for many of the projects discussed. When we asked each teacher about academic content connections made through their capstones during our debrief sessions, both teachers indicated that they struggled to find places to embed content expectations in RWC and Math due to the highly variable topics and activities pursued by students in their projects. As noted by Ms. Ramos, "we designed this capstone course to give students the opportunity to explore any topic of interest, but we haven't figured out how to ensure that they are demonstrating graduation readiness on RWC and math standards."

Cottonwood High

When we visited Ms. Strauss's school, the Fall semester-end was about a month away, yet the majority of students were either still in the ideation stage or had not started their projects. At Cottonwood, students received a mentor selection guidance document as well as some software suggestion resources (i.e. Canva, Powerpoint, google slides, etc.) to develop their final presentations. However, in contrast to Ash, students did not receive planning tools or other guidance documents at that point in time, to effectively support them in completing their projects. Ms. Strauss developed a rubric to evaluate the research paper required as part of the capstone course. But this rubric focused solely on evaluating superficial qualities (e.g., grammar and formatting) of the paper rather than substantive, standards-based aspects of the written work such as: how well the student could interpret and synthesize information from selected sources to support a position or viewpoints shared about the topic, or to what extent students used diverse research strategies to check and evaluate the credibility of sources selected. At the time we visited the school, this rubric had not yet been shared with students. Based on the few capstone documents shared with students, we had difficulty finding information that communicated any clear expectations for students to design and complete their capstone projects.

To effectively engage in capstone activities, students need clear instruction to develop necessary skills and receive adequate feedback to reflect on their progress (Harada, 2016; Eppes & Milanovic, 2011). The observed activities organized by Ms. Strauss focused on providing students with the opportunity to improve their work through peer feedback circles. However, these activities fell short of meeting what Harada (2016) and Eppes & Milanovic (2011) envisioned for capstones since she did not model or provide explicit instruction to students on how to give and receive peer feedback nor did she clarify or explain how the student-designed projects needed to connect to academic content as stipulated in the capstone project plan description. For example, the peer feedback activity asked students to work in small groups to share feedback with each other and identify at least one way in which they could help their peers complete their project. When students sat down to complete the peer feedback task, students expressed their confusion around engaging with the activity and one student told her small-group peers "I don't really know how I could help you with your project." Some students in the class appeared to be caught off guard by the peer feedback activity since several students were not sure how they could help one another when they had not started their projects.

For the few students that started their projects, they shared information about a variety of projects that served the community in different ways, such as: hosting a skateboard workshop to activate interest in skateboarding for youth, painting a mural for a preschool, promoting community food drives, and establishing a community recreation center using input from the larger community. Although many of these projects met one criterion outlined in the capstone project plan description (i.e., serving the community), we could not discern how students were designing their project to also meet the other capstone requirement around "demonstrating proficiency" on grade level math and RWC content. Although academic content connections could potentially be made for several of these projects, the feedback protocol did not encourage students to discuss or consider these connections. When Ms. Strauss visited each feedback circle; she also did not ask any her students any questions about how the student designed projects could fulfill the capstone requirement around meeting grade level ELA and/or Math expectations. Our observations and review of the few capstone documents available at this school affirm a point highlighted in the capstone literature underscoring the importance of making students aware of what is expected of them and giving them opportunities to understand success criteria for high-quality capstone completion (Johari, 2017; Lai, 2012). The lack of clarity and confusion expressed by students around task objectives combined with the lack of academic rigor embodied in many of the projects proposed or designed by her students, is not entirely surprising given that students did not appear to receive the necessary supports and structures from Ms. Strauss. When we asked Ms. Strauss about where academic content expectations would be met through the student designed projects, she acknowledged that she did not "know how to integrate content standards" into the activities or lessons planned in the capstones as currently designed.

To specifically answer our first research question, our findings indicate that the capstones we observed did provide students with great latitude to drive and establish capstone projects of interest to them. As indicated in the literature, providing students at this upper grade level with the independence to develop these projects and to pursue a topic of interest to them are important to ensure that these experiences reflect authentic and engaging experiences for students. However, clear expectations and structures are still needed to help guide students in this work and in one school (Cottonwood), building those expectations and structures will be a critical growth area to monitor for the school. Literature on high-quality capstone experiences stresses the importance of teachers building student familiarity with project expectations, using various structures such as rubrics, feedback activities, and questioning techniques to verify that students understand task objectives, and providing tasks and lessons that scaffold students into mastering the content and skills necessary to complete the capstone (Harada, 2016; Johari, 2017; McNeill, 2011; Chin et al., 2017). In Ash, these expectations and structures were established for students. In Cottonwood, these expectations and structures were either absent or poorly enacted and this resulted in observing classrooms where many students appeared largely confused about the task and project expectations for the capstone projects.

For both schools, another growth area for this capstone work is for the capstone designers at both sites to revisit the integration work between capstones and PBAs if these sites should decide to formally declare using capstones as an option to demonstrate graduation readiness. Regardless of the menu option selected, CDE Graduation Guidelines expect students to demonstrate college and career readiness through showcasing mastery of high school math and ELA (CDE, 2022a). Although CDE Graduation Guidelines note that math and ELA mastery demonstrations can

be individualized to the student within capstones, there is an explicit expectation that students will be able to showcase high school level math and ELA competency when using PBAs, such as what these two sites had done. However, as noted in the findings section, we did not observe teachers incorporating academic content into their capstones through the PBA work, and our debriefs of our observations with teachers confirmed this. During our debrief with the lead capstone instructor at Ash, Ms. Ramos, she discussed the lack of structures and inadequate guidance that could be found from the state to construct a rigorous capstone experience. She explained that the capstone structures at Ash Innovation drew from examples of capstone courses from other districts, which were skills driven. At Cottonwood, our debrief with the lead capstone instructor there confirmed that these experiences as currently designed did not require students to demonstrate academic content mastery. At these two sites, it became apparent that since a rigorous capstone curriculum had not yet been developed at these two high schools or by the district, these teachers struggled to apply principled approaches to designing the course with curriculum-embedded assessments or PBAs. This finding underscores the points raised by several authors (Harada, 2016; Johari, 2017; McNeill, 2011; Chin et al., 201) about the need for professional development and training for teachers to implement and support high-quality capstone experiences.

Discussion

It is important to be reminded of the aspirations and expectations surrounding capstones in Colorado. From the moment capstones were added as a graduation guideline pathway, capstones were intended to be rigorous demonstrations of students' academic content knowledge and skills and essential skills, showcasing readiness for PWR within the context of a student-selected topic. This inherently necessitates capstone experiences that challenge students to comprehensively and authentically demonstrate mastery of high school level content and the essential skills. As CDE and postsecondary institutions move away from relying on evaluating PWR with traditional standardized tests and move towards comprehensive indicators of PWR, each district may be challenged by their respective boards, parents, and other community stakeholders to defend capstones as demonstrating content and both essential and academic skill mastery (Soares, 2012). For capstones that are intended to be a skills-driven experience aimed at giving students the opportunity to freely pursue ideas and careers that interest them, a more fluid, diversely interpretable capstone structure could be considered appropriate or even ideal (Keller, Chan & Parker, 2010). But if more districts and schools turn to capstones to provide evidence of sufficiency for meeting graduation requirements, districts in partnership with their schools will need to establish clear guidance including professional development opportunities to schools on how to develop capstones that meet the high-quality features discussed in the literature (Dunbar, Koretz, & Hoover, 1991; Moss, 1994; Moss, 1992).

The Need to Strengthen District Capstone Guidelines

Establishing clear district guidance and support to schools is especially important when the district and/or schools want to integrate PBAs as demonstrations for meeting academic competencies through capstone projects. For districts and schools that contend that the capstones and embedded PBAs meet graduation requirements, the onus would fall on those entities to provide evidence that the PBAs used for capstones reflect "valid measures of individuals' higher order

thinking and [content] performance abilities…[and] can thereby predict [student] success on complex tasks more effectively" (p. 4, Guha et al., 2018). At Ash Innovation and Cottonwood, the planning, completion, and presentation of the final capstone project represented different tasks that comprise the performance assessment for the course. However, since many of the student designed projects did not require the completion of complex higher order tasks nor did they provide grade-level demonstrations of academic content, the capstone projects in their current shape at these two sites would likely not meet the PBA requirements outlined by CDE.

Adherence to Graduation Guidelines?

To answer our second research question, our case study findings indicate the capstone models we observed hold great potential for meeting the aspirations for capstones and PBAs established by CDE if substantial changes are made to improve capstone curriculum and structure. The lack of rigor and content connections made in the observed capstones at two sites present barriers, not only for embedding PBAs into the capstone curriculum, but also for the potential of capstone to serve as a more comprehensive evaluation of PWR. The capstones we observed were not intentionally designed to engage students in academically rigorous experiences. The type of projects that many observed students wanted to execute did not demand deeper explorations of the topic connected to content (e.g., preparing cakes for a bake sale). While students may organically apply academic content and skills, the teachers at the case study sites did not set clear expectations around connections between academic content and project topics, which is required in the menu of options for capstones and even more so for PBAs.

The documented activities taking place at the case study sites reveal that the capstones observed focused more on skills development rather than on academic content. Our conversations with the CDE Graduation Guidelines manager as well as with teachers suggest that the capstone projects we observed in our case study are not uncommon across Colorado districts. At Ash, the capstone projects at that school were modeled using the capstone designs from other school districts. However, the manager also noted that there are some exceptional districts that do provide academically demanding capstone experiences. This acknowledged variability in the quality of capstone experiences offered across districts and schools underscores the likelihood that capstone expectations vary widely across schools and highlights the need to clarify guidance for capstones and PBAs and support schools in meeting quality standards.

Capstones in Support of Equity

Capstones can serve as a rich area for fostering equitable learning experiences. Ideally, the high level of autonomy given to students over the capstone process coupled with connecting capstones to applied work or to solving real-world problems, can make capstones authentic, enabling students to critically investigate questions aligned with their interests, passions, and lived experiences. Capstones designed with cognitively demanding expectations and adequate supports to meet project objectives, can result in deep learning and yield more comprehensive demonstrations of what students know and can do relative to the narrow subset of content devoid of essential skills evaluated by traditional standardized tests. This process holds promise to promote equity by providing students with a meaningful opportunity to tailor a learning experience to their own pace, needs, and considerations while also drawing connections between real-world issues and academic content. As various aspects (such as the time, format, and context) of traditional standardized tests, like SAT or ACT, can often serve to further marginalize minoritized youth by limiting learning demonstrations to a single-time-point assessment observation (Kearns,

2011), capstones can emerge as a promising avenue for promoting equity in the context of high stakes indicators used to determine whether students meet exit criteria like college and career readiness.

While capstones and PBAs have been cited in the literature as helpful pathways for promoting equity and supporting diverse groups of students in rigorously developing and demonstrating PWR skills, researchers discuss the importance of providing appropriate structures for students to meaningfully engage in these experiences (Guha, 2018; Guha et al., 2018; Duke et al., 2021; Diaz-Bilello & Pierre-Louis, 2021). Scholars warn that inequities can be exacerbated within the context of alternative assessments, like PBAs and capstones, when students are not adequately supported to take advantage of these PWR demonstration opportunities (Guha et al., 2018). If the responsibility rests largely on the student to identify and ensure that they are meeting academic and essential skill expectations for PWR, disparities are more likely to occur as all students may not have built sufficient prior knowledge to develop project experiences that would meet rigorous PWR content demands (Guha et al., 2018; Darling-Hammond & Adamson, 2010).

In the classes we observed, we saw some benefits of capstones being harnessed to motivate student learning and engagement, but teachers would need to do more to access the potential of capstones to promote equity by providing these students with rigorous opportunities to learn. While students were given autonomy to explore topics of personal interest to them and were juggling various project elements in their own ways, we observed two, primarily skills-driven capstone models that could be substantially improved by increasing capstone rigor and expectations for all students. A skills-driven capstone can certainly have its merits for providing an oasis for students to explore their interests related to future pursuits in college or industry (Keller, Chan & Parker, 2010). However, capstones that exclusively focus on skills (without academics) is not fully aligned with state aspirations for capstones which requires demonstration of mastery in RWC and Math. In these cases, districts would need to specify additional supportive evidence (e.g., from portfolios) to ensure that academic content and skills are being met through other avenues and courses.

Furthermore, the literature on capstones and PBAs as a tool for equity promotion emphasizes the need for structures, supports, and resources to be made available to teachers to support them in successfully maximizing the potential for equity in capstones and PBAs (Koretz,, Stecher & Deibert, 1992; Afflerbach, Kapinus & DeLain, 1995). Equity aims can be best achieved through performance assessments when they are implemented within a broader, coherent system conducive to fostering growth across students, teachers, and schools (Darling-Hammond, 1994; Reardon, Scott & Verre, 1994). However, as we have noted above, the policies and guidance supporting capstones are often vague and inconsistent to teachers and districts. To expand on this, below we discuss the need to improve the infrastructure surrounding capstones to broadly signal the importance of establishing high-quality capstone processes to the field.

Strengthening the Capstone Instructional Infrastructure

The capstone experiences described in the case studies exemplify scenarios that reveal the pitfalls of implementing this work when the instructional guidance infrastructure (Hopkins & Spillane, 2015) is discretionary at the state level, and lacks specificity at the district and school levels. Instructional guidance infrastructures (IGIs) consist of the array of artifacts and components supporting the infrastructure of instructional practices taking place in a school or district such as instructional

frameworks, learning standards, curricula, assessments, and professional learning communities established (Cohen, 2011; Mehta & Fine, 2015; Penuel, 2018). At the state level, the highly decentralized and flexible capstone IGI advanced by the state was intended to allow local districts and schools to customize the instructional guidance at their discretion. Although this model conforms with the local control policy in place at the state, this model could also set the stage for establishing large variation in the IGIs designed by districts and schools which could contribute to differential experiences and outcomes for students participating in capstones across the state.

At these two case study sites specifically, the broad infrastructure set for the capstone work by the state coupled with the lack of a clear infrastructure established by either the school (for both sites) or district (for one site) put the teachers in a position where they are left with the burden to design the infrastructure for this graduation menu option. Cohen & Spillane (1992) note that in the absence of coherent infrastructure guiding instructional initiatives, such as the capstone work, these initiatives can become guided by teachers' inherited practices and individual decisions rather than from a clear vision guiding the planning and implementation work. In these two case study schools, due to not having a clear IGI established for the capstones, the capstone work enacted became shaped solely through the inherited practices and individual decisions of these individual teachers which also led to differential outcomes for their students.

The results of these two studies point to the importance of establishing a clear IGI to support the capstone work. Regardless of the emphasis and vision for the capstone work, building out a robust IGI is important for providing all capstone teachers with a common foundation for the work (Cohen, 2011; Cohen et al., 2013; Hopkins & Spillane, 2015). If the district and school vision for a capstone experience is to provide students with important work experiences that emphasizes essential skills rather than disciplinary content knowledge and skills, then the stated policies as well as the learning and assessment experiences designed should cohere to support that particular vision. However, if a district and school's vision for a capstone experience is to blend the essential skills with disciplinary content knowledge and skills through authentic and meaningful projects, then district and school leaders should work closely with their capstone instructors to ensure that this type of ambitious learning agenda is supported by a strong and common foundation to guide the learning environment and expectations established for this work.

The provision of capstones and PBAs as pathways to demonstrating PWR is important to preserve considering that current statewide assessment systems prioritize annual statewide standardized testing, which tends to discourage culturally relevant and authentic learning approaches that all students need (Randall, 2021; Solano-Flores, 2011, 2019). That is, these student-centered pathways have great potential to advance more equitable approaches of evaluating graduation readiness compared to the more limited content, formats and modalities offered by traditional standardized tests and exams. Capstones can be uniquely well-positioned as a fertile area for high schools to advance essential and academic skills and content while also giving all students a chance to deeply explore an interest or industry they may pursue after graduation. These experiences can improve student confidence, increase engagement, help them find their purpose, and prepare them for their future in ways that may not be accessible in traditional coursework (Pellissier, 2021). To realize this potential, we outline several suggestions for CDE to consider for promoting high-quality capstone processes throughout the state.

Capstone Considerations for CDE

We conclude this paper with several suggestions for CDE to consider in light of the capstone experiences documented in the two sites at the early stages of establishing capstones for their students:

- Convene a stakeholder group to establish clarity and consensus around key features and elements that should be addressed by capstones designed by schools and districts to fulfill graduation requirements.

Like the stakeholder work convened earlier to establish clear guidance and features for the PBAs designed by districts and schools to fulfill graduation requirements, using state-wide stakeholder input on capstones can help clarify essential features that need to be addressed when designing these to meet graduation requirements. For example, if districts or schools would prefer to emphasize important essential skills through career experiences in the capstones, then these sites may need to supplement the capstones with a portfolio that could contain evidence of academic content mastery and skills.

As sites become increasingly interested in innovating their capstone practices, establishing a stakeholder group to clarify expectations around high-quality capstone experience is critical. To this end, for sites that wish to embed PBAs as part of capstone to demonstrate disciplinary content and skills mastery, those sites may be advised to look to the PBA guidance to ensure that they are meeting the expectations set for the PBAs. A critical expectation that should be set for a capstone that integrates PBAs is to provide opportunities for students to apply and transfer content knowledge and skills to other disciplinary areas and contexts by leveraging the essential skills acquired through the project work.

In addition to receiving guidance from a capstone stakeholder group, sites can also be connected to other CDE partners such as the Colorado Education Initiative to receive guidance on integrating PBAs as part of capstones. Having a stakeholder group identify critical capstone features would allow CDE to establish clearer statewide expectations for capstones, but still maintain the creative autonomy of districts and schools to design experiences that align with those expectations.

- Revisit and update the current Capstone guidance

The capstone guidance established by the state was developed in 2014 and should likely be revisited since several changes, such as the introduction of new academic standards and specification of essential skills, have taken place since then and would directly influence the design of capstones meeting graduation requirements. The work of revisiting and updating the capstone guidance could be done as part of the stakeholder group work suggested above so that this guidance is aligned with outcomes achieved by that group. As indicated by the capstone designer at Ash, sharing clearer guidance for the capstone development work would provide a much-needed resource for places that cannot get clear direction or support from either the district or other authorities.

- Encourage districts or other authorizing entities (e.g., the Charter School Institute for charter schools) to conduct periodic peer reviews to check on the quality of capstone experiences implemented at schools.

In the specific case of the two case study schools piloting capstones, the trial work this year fell short

of meeting the aspiration of providing a rigorous experience that allowed students to engage in projects that enabled deeper disciplinary connections. Since CDE cannot conduct any quality checks around this work, CDE should consider partnering with districts and other authorizing entities to help them become familiarized with guidance and criteria that can be used to ensure that implemented capstones reflect experiences that meet PWR expectations. Encouraging districts and other authorizing entities to conduct capstone peer reviews would be helpful for identifying or showcasing capstone demonstration sites for learning purposes. This review would also provide an important check to ensure that students participating in capstones are receiving an equitable learning experience that will clearly prepare them for their next journey in life after high school.

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About CADRE

The Center for Assessment, Design, Research and Evaluation (CADRE) is housed in the School of Education at the University of Colorado Boulder. The mission of CADRE is to produce generalizable knowledge that improves the ability to assess student learning and to evaluate programs and methods that may have an effect on this learning. Projects undertaken by CADRE staff represent a collaboration with the ongoing activities in the School of Education, the University, and the broader national and international community of scholars and stakeholders involved in educational assessment and evaluation.

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References

ACT. (2006). *Ready for college, ready for work: Same or different*. ACT. https://files.eric.ed.gov/fulltext/ED491591.pdf

Afflerbach, P., Kapinus, B., & DeLain, M. (1995). Reading Assessment: Equity and Performance-Based Assessment: An Insider's View. *The Reading Teacher, 48*(5), 440-442. Retrieved May 6, 2021, from http://www.jstor.org/stable/20201461

Aguinis, H., Culpepper, S. A., & Pierce, C. A. (2016). Differential prediction generalization in college admissions testing. *Journal of Educational Psycholog, 108*(7), 1045-1059. http://dx.doi.org/10.1037/edu0000104

American Diploma Partnership (ADP). (2004). Ready or not: Creating a diploma that counts. https://files.eric.ed.gov/fulltext/ED494733.pdf

Baines, A., Haydel DeBarger, A., De Vivo, K., Warner, N., Brinkman, J., & Santos, S. (2015). *What is rigorous Project-Based Learning?* George Lucas Educational Foundation. http://ler.s3.amazonaws.com/Rigorous+PBL+Position+Paper.pdf

Barnes, W., & Slate, J. R. (2013). College-readiness is not one-size-fits-all. *Current Issues in Education*, 1-11. https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.854.7026&rep=rep1&type=pdf

Bowman, A. J. (1989). The MPA capstone experience: The essence of analysis is surprise. *Review of Policy Research, 8*(4), 920-928. https://doi.org/10.1111/j.1541-1338.1989.tb01012.x

Buchanan Hill, J. (2016). Questioning techniques: A study of instructional practice. *Peabody Journal of Education, 91*(5), 660-671. https://doi.org/10.1080/0161956X.2016.1227190

Buzzetto-More, N. (2013). Models to inform capstone program development. *Proceedings of the Informing Science and Information Technology Education Conference*, 81-93. https://www.learntechlib.org/p/114663/

Camara, W. (2013). Defining and measuring college and career readiness: A validation framework. *Educational Measurement: Issues and Practice, 32*(4), 16-27.

Camara, W., & Mattern, K. (2022). Inflection point: The role of testing in admissions decisions in a postpandemic environment. *Educational Measurement: Issues and Practice, 0*(0), 1-6. https://doi.org/10.1111/emip.12493

Cañon City High School. (2020). *The Pathways at Cañon City High School.* https://campussuite-storage.s3.amazonaws.com/prod/1559007/be93858e-5cb0-11ea-aec8-127d75a5caed/2129614/382bdc44-c6af-11ea-8de3-0aa4a8eac247/file/2020-21%20FINAL%20Pathways%20Handbook.pdf

Chang, J.C. (2019). The instructional design and effects of capstone project course embedded inquiry-based learning in technical high school. *US-China Education Review A, 9*(2), 41-64. https://pdfs.semanticscholar.org/4fa8/7d6f0da2501b3a6332fed60a94a41758d726.pdf

Chin, J., Zeid, A., Duggan, C., & Kamarthi, S. (2011). A unique methodology for implementing high school capstone experiences through teacher professional development. *American Journal of Engineering Education, 2*(2), 17-30.

Chingos, M. M. (2018). *What matters most for college completion?: Academic preparation is a key predictor of success* (F. M. Hess & L. E. Hatalsky, Eds.). AEI. https://www.aei.org/wp-content/uploads/2018/05/What-Matters-Most-for-College-Completion.pdf

Cohen, D. K., & Spillane, J. P. (1992). Policy and practice: The relations between governance and instruction. *Review of Research in Education, 18*(1), 3-47.

Cohen, D. K. (2011). *Teaching and its predicaments.* Cambridge, MA: Harvard University Press.

Cohen, D. K., Peurach, D. J., Glazer, J. L., Gates, K. E., & Goldin, S. (2013). *Improvement by design: The promise of better schools.* Chicago, IL: University of Chicago Press.

Colorado Department of Education (CDE), Portfolio and Capstone Guidebook, A. (Colo. July, 2014). https://www.cde.state.co.us/postsecondary/portfolio-and-capstone-draft-implementation-guidebook

Colorado Department of Education (CDE). (2021a). *Menu of college and career-ready demonstrations.* https://www.cde.state.co.us/postsecondary/graduationguidelinesmenuofoptions10-01-21pdf

Colorado Department of Education (CDE). (2021b). *Colorado Essential Skills.* https://www.cde.state.co.us/standardsandinstruction/revisedcoloradoessentialskills

Colorado Department of Education (CDE). (2022a). *Graduation Guidelines - Capstone.* Retrieved April 25, 2022, from https://www.cde.state.co.us/postsecondary/grad-capstone

Colorado Department of Education (CDE). (2022b). *Collaboratively-developed, Standards-based Performance Assessment*. https://www.cde.state.co.us/postsecondary/perfassessment

Croizet, J.C. Millet, M. (2016) Social Class and Test Performance: From Stereotype Threat to Symbolic Violence and Vice Versa [Chapter]. *Stereotype Threat: Theory, Process and Application* (188-201). Oxford University Press. https://halshs.archives-ouvertes.fr/halshs-00983906/document

Darling-Hammond, L. (1994). Performance-based assessment and educational equity. *Harvard Educational Review, 64*(1), 5-30. doi:https://doi.org/10.17763/haer.64.1.j57n353226536276

Darling-Hammond, L., Herman, J., Pellegrino, J., et al. (2013). *Criteria for high-quality assessment.* Stanford, CA: Stanford Center for Opportunity Policy in Education

Darling-Hammond, L., Wilhoit, G., & Pittenger, L. (2014). *Accountability for College and Career Readiness: Developing a New Paradigm.* National Center for Innovation in Education Faculty Publications. 1. https://uknowledge.uky.edu/ncie_facpub/1

Darling-Hammond, L., & Adamson, F. (2010). Beyond basic skills: The role of performance assessment in achieving 21st century standards of learning. Stanford, CA: Stanford University, Stanford Center for Opportunity Policy in Education

Diaz-Bilello, E., & Pierre-Louis, M. (2021). *Using performance-based assessments to advance teaching and learning in high school classrooms.* Colorado Department of Education. https://www.cde.state.co.us/postsecondary/pacasestudypaper3

Dugan, R. F., Jr. (2011). A review of literature on teaching engineering design through project-oriented capstone courses. *Computer Science Education, 21*(3), 201-267.

Duke, N. K., Halvorsen, A. L., Strachan, S. L., Kim, J., & Konstantopoulos, S. (2021). Putting PjBL to the Test: The Impact of Project-Based Learning on Second Graders' Social Studies and Literacy Learning and Motivation in Low-SES School Settings. *American Educational Research Journal, 58*(1), 160–200. https://doi.org/10.3102/0002831220929638

Dunbar, S.B., Koretz, D.M. & Hoover, H.D. (1991). Quality Control in the Development and Use of Performance Assessments. *Applied Measurement in Education*,(4)4, 289-303, DOI: 10.1207/s15324818ame0404_3

Dunlap, J. C. (2005). Problem-based learning and self-efficacy: How a capstone course prepares students for a profession. *Educational Technology Research and Development, 53*, 65-83. https://doi.org/10.1007/BF02504858

Eppes, T. A., & Milanovic, I. (2011). Capstone design project course pathways. *American Journal of Engineering Education, 2*(1), 35-42. https://files.eric.ed.gov/fulltext/EJ1058169.pdf

Evans, M., & Boucher, A. R. (2015). Optimizing the power of choice: Supporting student autonomy to foster motivation and engagement in learning. *Mind, Brain, and Education, 9*(2), 87-91. https://onlinelibrary.wiley.com/doi/full/10.1111/mbe.12073

Farrell, V., Ravalli, G., Farrell, G., Kindler, P., & Hall, D. (2012). Capstone project: Fair, just and accountable assessment. In *ITiCSE '12: Proceedings of the 17th ACM annual conference on Innovation and technology in computer science education* (pp. 168-173).

Fine, M., & Pryiomka, K. (2020, July). *Assessing college readiness through authentic student work: How the city university of new york and the New York performance standards consortium are collaborating toward equity.* Learning Policy Institute. https://files.eric.ed.gov/fulltext/ED606677.pdf

Fraile, J., Panadero, E., & Pardo, R. (2017). Co-creating rubrics: The effects on self-regulated learning, self-efficacy and performance of establishing assessment criteria with students. *Studies in Educational Evaluation, 53*, 69-76. https://www.sciencedirect.com/science/article/pii/S0191491X1630205X

Friesen, S., & Scott, D. (2013). *Inquiry-based learning: A review of the research literature*. Alberta Ministry of Education. https://galileo.org/focus-on-inquiry-lit-review.pdf

Ford, R. M., & Lasher, W. C. (2004) "Processes for ensuring quality capstone design projects," *34th Annual Frontiers in Education, 2004*. FIE 2004. pp. S2G12-S2G17, doi: 10.1109/FIE.2004.1408743.

Geiser, S. (2009). Back to the basics: In defense of achievement (and achievement tests) in college admissions. *Change: The Magazine of Higher Learning, 41*(1), 16-23. DOI: 10.3200/CHNG.41.1.16-23

Guna, R. (2018). Reimagining assessment: The power and promise of performance assessments. *Next Generation Learning Challenges (NGLC).* https://www.nextgenlearning.org/articles/the-power-and-promise-of-performance-assessments

Guha, R., Wagner, T., Darling-Hammond, L., Taylor, T., & Curtis, D. (2018). *The promise of performance assessments: Innovations in high school learning and college admission*. Learning Policy Institute. https://files.eric.ed.gov/fulltext/ED606783.pdf

Hammer, S., Abawi, L., Gibbings, P., Jones, H., Redmond, P., & Shams, S. (2018). Developing a generic review framework to assure capstone quality. *Higher Education Research & Development, 37*(4), 730-743.

Harada, V. (2016). A practice-centered approach to professional development: Teacher librarian collaboration in capstone projects. *School Library Research, 19*, 1-47. https://files.eric.ed.gov/fulltext/EJ1120876.pdf

Henning, J. A. (2016). *A case study: Learner capacities from a capstone senior project* (Order No. 10162020) [Grand Canyon University]. Available from ProQuest Central; ProQuest Dissertations & Theses A&I; ProQuest Dissertations & Theses Global; Publicly Available Content Database. (1842430637). Retrieved from https://colorado.idm.oclc.org/login?url=https://www.proquest.com/dissertations-theses/case-study-learner-capacities-capstone-senior/docview/1842430637/se-2

Hernández, L. E., Darling-Hammond, L., Adams, J., & Bradley, K. (with Duncan Grand, D., Roc, M., & Ross, P.). (2019). *Deeper learning networks: Taking student-centered learning and equity to scale.* Palo Alto, CA: Learning Policy Institute.

Hopkins, M., & Spillane, J. P. (2015). Conceptualizing relations between instructional guidance infrastructure (IGI) and teachers' beliefs about mathematics instruction: Regulative, normative, and cultural-cognitive considerations. *Journal of Educational Change, 16*(4), 421-450.

Jalomo, R., Jr. (2000). Assessing minority student performance. *New Directions For Community Colleges, 2000*(112), 7-17. https://onlinelibrary.wiley.com/doi/abs/10.1002/cc.11201

Johari, P. (2017). Case study: The capstone project at Chelsea High School. Voices in Urban Education, 46, 44-47. https://files.eric.ed.gov/fulltext/EJ1148459.pdf

Kannapel, P. (2012). *High school capstone Courses: A review of the literature.* Edvantia. https://files.eric.ed.gov/fulltext/ED539346.pdf

Kearns, L. (2011). High-stakes standardized testing and marginalized youth: An examination oF the impact on those who fail. Canadian Journal of Education, 34(2), 112-130. https://www.jstor.org/stable/pdf/canajeducrevucan.34.2.112.pdf

Keller, S., Chan, C. & Parker, C. (2010). Generic skills: Do capstone courses deliver? In M. Devlin, J. Nagy and A. Lichtenberg (Eds.) *Research and Development in Higher Education: Reshaping Higher Education, 33* (pp. 383–393). Melbourne, 6–9 July, 2010.

Kingston, S. (2018). Project-Based Learning & Student Achievement: What Does the Research Tell Us? *PBL Evidence Matters.* 1(1), 1-11. http://bie.org/x9JN

Koretz, D., Stecher, B., & Deibert, E. (1992). *The Vermont Portfolio Assessment Program: Interim Report on Implementation and Impact, 1991-92 School Year.* CSE Technical Report 350. National Center for Research on Evaluation, Standards, and Student Testing (CRESST).

Krajcik, J. S., & Blumenfeld, P. C. (2006). Chapter 19: Project-Based Learning. In R. K. Sawyer (Ed.), *The Cambridge Handbook of the Learning Sciences* (pp. 317-333). Cambridge University Press. https://knilt.arcc.albany.edu/images/4/4d/PBL_Article.pdf

Lai, E. R. & Viering, M. (2012). *Assessing 21st century skills: Integrating research findings*. Paper presented at the annual meeting of the National Council on Measurement in Education, Vancouver, B.C., Canada.

Lai, E. R. (2012). *Creating curriculum-embedded, performance based assessments for measuring 21st century skills in k-5 students* [Paper presentation]. American Educational Research Association. https://images.pearsonassessments.com/images/tmrs/Creating_Curriculum_embedded_PBAs_AERA.pdf

Lampert, M., & Graziani, F. (2009). Instructional activities as a tool for teachers' and teacher educators' learning. *Elementary School Journal, 109*(5), 491-509.

Linn, R. L., Baker, E. L., & Dunbar, S. B. (1991). Complex, Performance-Based Assessment: Expectations and Validation Criteria. *Educational Researcher, 20*(8), 15–21. https://doi.org/10.3102/0013189X020008015

Linn, R., Baker, E., & Dunbar, S.B. (1991). Complex, Performance-Based Assessment: Expectations and Validation Criteria. *Educational Researcher, 20*(8), 15 - 21.

Lombardi, A. R., Conley, D. T., Seburn, M. A., & Downs, A. M. (2013). College and Career Readiness Assessment: Validation of the Key Cognitive Strategies Framework. *Assessment for Effective Intervention, 38*(3), 163–171. https://doi.org/10.1177/1534508412448668

McArthur, J. (2016). Assessment for social justice: The role of assessment in achieving social justice. *Assessment & Evaluation in Higher Education, 41*(7), 967-981. DOI: 10.1080/02602938.2015.1053429

McNeill, M. (2011). Technologies to support the assessment of complex learning in capstone units: Two case studies [Chapter]. In: Ifenthaler, D., Spector, J., Isaias, P., Sampson, D., *Multiple Perspectives on Problem Solving and Learning in the Digital Age*. Springer. https://doi.org/10.1007/978-1-4419-7612-3_13

Mehta, J. D., & Fine, S. (2015). Bringing values back in: How purposes shape practices in coherent school designs. *Journal of Educational Change, 16*(4), 483-510. doi:10.1007/s10833-015-9263-3

Messick, S. (1982). Issues of effectiveness and equity in the coaching controversy: Implications for educational and testing practice. *Educational Psychologist, 17*(2), 67-91. https://doi.org/10.1080/00461528209529246

Moss, P. A. (1992). Shifting Conceptions of Validity in Educational Measurement: Implications for Performance Assessment. *Review of Educational Research, 62*(3), 229–258. https://doi.org/10.3102/00346543062003229

NCEE. (2003). *Slide 12 of America's Choice School Design Model Presentation* [Infographic]. NCEE. https://images.slideplayer.com/32/9839227/slides/slide_12.jpg

O'Grady, A. (1999). Information literacy skills and the senior project. *Educational Leadership, 57*(2), 61-62. https://www.proquest.com/docview/224849056

Pellissier, H. (2021). *The value of senior capstone projects.* Great Schools. https://www.greatschools.org/gk/articles/the-value-of-senior-capstone-projects/

Pembridge, J. J., & Paretti, M. C. (2011). An examination of mentoring functions in the capstone course. 2011 *ASEE Annual Conference & Exposition*, 22.173.1-22.173.16. https://peer.asee.org/an-examination-of-mentoring-functions-in-the-capstone-course

Randall, J. (2021). "Color-neutral" is not a thing: Redefining construct definition and representation through a justice-oriented critical antiracist lens. *Educational Measurement: Issues and Practice, 40*(4), 82-90. https://onlinelibrary.wiley.com/doi/full/10.1111/emip.12429

Randall, J., Poe, M. & Slomp, D. (2021). Ain't Ought to Be in the Dictionary: Getting to Justice by Dismantling Anti-black Literacy Assessment Practices. *Journal of Adolescent & Adult Literacy, 64*(5), 594– 599. https://doi.org/10.1002/jaal.1142

Reid Schwebach, J. (2008). Science seminar: Science capstone research projects as a class in high school. The *American Biology Teacher, 70*(8), 488-497. https://doi.org/10.1662/0002-7685(2008)70[488:SSSCRP]2.0.CO;2

Reardon, S.F., Scott, K. & Verre, J. (1994). Symposium: Equity in educational assessment. *Harvard Educational Review, 64*(1), 1. Retrieved from https://colorado.idm.oclc.org/login?url=https://www.proquest.com/scholarly-journals/symposium-equity-educational-assessment/docview/212295549/se-2?accountid=14503

Rhode Island Department of Education. (2018). *Secondary school regulations reference guide.* https://files.eric.ed.gov/fulltext/ED591451.pdf

Ruiz-Primo, M.A. & Furtak, E.M. (2006). Exploring teachers' informal formative assessment practices and students' understanding in the context of scientific inquiry. *Journal of Research in Science Teaching, 44*(1), 57-84.

Shepard, L. A. (2000). The Role of Assessment in a Learning Culture. *Educational Researcher, 29*(7), 4–14. https://doi.org/10.3102/0013189X029007004

Shepard, L.A., Penuel, W.R., & Pellegrino, J.W. (2018). Using learning and motivation theories to coherently link formative assessment, grading practices and large-scale assessment. *Educational Measurement, Issues and Practice, 37*(1), pp. 21-34.

Soares, J. A. (2012). The Future of College Admissions: Discussion. Educational Psychologist, 47(1), 66-70. https://www.tandfonline.com/doi/full/10.1080/00461520.2011.638902

Solano-Flores, G. (2011). Cultural Validity in Assessment — Basic Concepts. In M. R. Basterra, E. Trumbull, & G. Solano-Flores (Eds.), Cultural validity in assessment: A guide for educators (pp. 3–21). New York, NY: Routledge.

Solano-Flores, G. (2019). Examining Cultural Responsiveness in Large-Scale Assessment: The Matrix of Evidence for Validity Argumentation. Frontiers in Education, 4(June), 1–9.

Speckels, H. (2011). The impact of project-based learning on academic achievement for students with academic challenges at K–5 grade levels: A grounded theory revelation [Doctoral dissertation, Speckels, Hermie Fuller.Jones International University]. ProQuest Dissertations Publishing. https://www.proquest.com/docview/992879069

Suárez, A., Specht, M., Prinsen, F., Kalz, M., & Ternier, S. (2018). A review of the types of mobile activities in mobile inquiry-based learning. Computer and Education, 118, 38-55.

Tio, F., Kong, J., Lim, R., & Tio, E. (2014). Developing and applying rubrics for comprehensive capstone project assessment. *Proceedings of the 10th International CDIO Conference*, 1-12. http://staging.cdio.org/files/document/cdio2014/49/49_Paper.pdf

Toppo, G., T. (2020). Support builds for making the SAT untimed for everyone. *Education Next, 20*(1). https://www.educationnext.org/support-builds-making-sat-untimed-for-everyone-possible-solution-gaming-the-system/

Tsekeris, C. (2019). Surviving and thriving in the Fourth Industrial Revolution: Digital skills for education and society. *Homo Virtualis, 2*(1), 34-42. https://ejournals.epublishing.ekt.gr/index.php/homvir/article/view/20192/17866

Wathington, H. D., Barnett, E. A., Fay, M. P., Mitchell, C., Pretlow, J., & Bork, R. H. (2012). *Preparing students for college learning and work: Investigating the capstone course component of Virginia's college and career readiness initiative.* National Center for Postsecondary Education.

Wheatley, W. J., Roberts, R. M., & Einbecker, R. C. (1990). A Complex Simulation and Community Involvement Yield an Award-Winning Capstone Experience. *Simulation & Gaming, 21*(2), 181–189. https://doi.org/10.1177/1046878190212005

Wiggins, G. (1990). The case for authentic assessment. *Practical Assessment, Research, and Evaluation, 2*. https://doi.org/10.7275/ffb1-mm19

World Economic Forum. (2016, January). *The future of jobs: Employment, skills and workforce strategy for the Fourth Industrial Revolution*. World Economic Forum. https://www3.weforum.org/docs/WEF_Future_of_Jobs.pdf

Wyatt, J., Kobrin, J., Wiley, A., Camara, W. J., & Proestler, N. (2011). *SAT benchmarks: Development of a college readiness benchmark and its relationship to secondary and postsecondary school performance*. The College Board. https://files.eric.ed.gov/fulltext/ED521173.pdf

Zeid, A., Kamarthi, S., Duggan, C., & Chin, J. (2011). Capsule: An innovative capstone-based pedagogical approach to engage high school students in STEM learning. *ASME 2011 International Mechanical Engineering Congress & Exposition.* https://stem.neu.edu/wp-content/uploads/2015/12/CAPSULE-An-innovative-capstonebased-pedagogical-approach-to-engage-high-school-students-in-STEM-learning.pdf

Zwick, R. (2022). A Century of Testing Controversies 1. In B. E. Clauser & M. B. Bunch (Eds.), *The history of educational measurement: Key advancements in theory, policy, and practice* (pp. 136-154). Routledge. https://doi.org/10.4324/9780367815318