



Impact of Articulation Agreements on Student Transfer between Higher Education Institutions: A Case Study of a Cybersecurity Program

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ABSTRACT

Cybersecurity education has grown exponentially over the past decade. This growth occurred at all levels of education – from high schools to community colleges to four-year universities. At the same time, renewed interest in helping students transfer between higher education institutions has resulted in calls from policy makers and higher education leaders to create seamless pathways for students. Aligning cybersecurity education with changes in the transfer landscape, a case study was conducted to provide a framework for understanding how to improve services to cybersecurity transfer students. The case study involved four components: a review of articulation agreement literature, a review of processes used in the authors’ home institutions, a review of our experiences with the cybersecurity articulation agreement process, and recommendations for future articulation agreements.

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Over the past two decades, two systemic changes operating in different societal systems have shaped the landscape of cybersecurity education. On the one hand, changes in the technological system have dramatically altered the way individuals use technology, the degree to which we rely on those technologies, and the way that these technologies have influenced our behaviors. Inherent within these technological changes is the degree to which the electronic and computer technological changes have created new risks for individuals, businesses, government agencies, and other entities benefitting from technological growth. Criminals from across the world can access information through our computer networks and information is much more readily available for misuse. More specifically, the need to provide cybersecurity for these aforementioned entities has now become a reality that cannot be taken for granted. The need for cybersecurity has resulted in an increased number of careers in the cybersecurity field. In fact, there are now well over 500,000 cybersecurity job openings in the United States (Cyberseek US, 2020). The educational requirements for these jobs range from high school diplomas to certifications to associates degrees to bachelor’s and graduate degrees. The fact that there are so many job openings means that higher educational institutions have not been able to meet the existing demand, regardless of the level of education required for specific jobs.

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On the other hand, while technological changes have produced the need for cybersecurity education to protect against cyber attacks, cybercrime victimization, and information breaches, changes in the educational system, coupled with demographic and social changes, have led to interest in helping students to navigate between higher education institutions. In the past, interest in transfer students was limited to a handful of institutions. Over the past decade, policy makers, legislators, and

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foundations such as the Gates Foundation and Lumina Foundation have called upon higher education institutions to improve the ability of students to transfer between those institutions (Smith, 2017).

At the same time, research by Fincher et al. (2014), exploring how institutions fare in terms of articulation, has provided a framework to help us understand the value of articulation policies and practices at the institutional level. Building on this important body of research, it is important to consider how articulation policies and practices operate at the unit level between institutions' academic degree programs.

Merging the growth of cybersecurity education together with calls for more seamless delivery of transfer services for higher education students, this article describes a case study conducted in order to provide a framework for understanding how to improve services to cybersecurity transfer students. The case study included a review of literature on articulation agreements, a review of articulation agreement processes at the authors' home institutions, a review of our experiences with the development and implementation of cybersecurity articulation agreement processes, and recommendations for future articulation agreements.

Review of literature

Various types of articulation have been in place for more than a century, though the varieties and motives for their use have changed over time (Mosholder & Zirkle, 2007). The traditional articulation agreement involves students getting an AA or AS that covers general education requirements and allows students to transfer their coursework into a four-year institution. Overtime, more community college students on technical tracks have become interested in transferring to a Bachelor's degree program at some point (Zinser & Hanssen, 2006). The academic literature on articulation agreements is replete with reviews and studies on various topics aiming to better understand and improve the policies and processes guiding interinstitutional transfer credits. Generally, this literature can be divided into the following categories: conceptualizing articulation, the value of articulation, articulation and policy, the faculty role in articulation agreements, and challenges with articulation.

Conceptualizing articulation

The literature on conceptualizing articulation focuses on different ways that articulation is defined. As the most basic level, articulation agreement is a "curriculum roadmap" (Just & Adams, 1997, p. 36). Such a definition provides a simple and straightforward foundation to understand what articulation agreements do. However, the nature of articulation agreements, their value, and the amount of work needed to create them must also be considered. As an illustration, consider the following articulation agreement definitions:

- "Articulation is the process of coordinating curricula at different levels of education in order to foster the efficiency and effectiveness of the educational process" (Mosholder & Zirkle, 2007, p. 732).
- "Articulation is a coordinated effort and process to support efficient transfer between institutions of higher education" (Fincher et al., 2014, p. 684)
- "Articulation agreements are principal instruments to facility the transfer process ... [and] negotiate the requirements for students' movement from institution to institution and support the transfer intent" (Anderson et al., 2006, pp. 262–263).

These definitions highlight four important aspects of articulation agreements. First, the agreements involve a process of coordination between different parties. Second, the agreements align coursework between different educational levels. Third, the agreements are tools (or instruments) that students and advisors use to communicate course equivalencies. Finally, articulation agreements are designed to promote efficiency for students while promoting effective learning. In short, in addition to being

a roadmap, articulation is a process and tool aligning coursework between higher education institutions so students can transfer between institutions and the most cost-effective and timely manner possible.

The value of articulation

The existing literature on articulation agreements has explored numerous advantages of articulation with individuals, institutions, and communities reaping the benefits of articulation (Zinser & Hanssen, 2006). These advantages include affordability, better paying careers, efficiency, enhanced social mobility, synergism, and flexibility.

Affordability is perhaps the most cited advantage of articulation agreements. In particular, when implemented correctly, articulation should save transferring students money. Consider that the average tuition costs of community colleges are nearly one-third that of the average cost of tuition in four-year schools (Patton, 2017). What this means is that the more transferable courses that students take at the community college, the less they have to pay in the long run for a bachelor's degree (Lipscomb et al., 2019). In fact, the rising cost of four-year universities, coupled with simultaneous reductions in state support for higher education, has been cited as one of the reasons for the growth of articulation agreements (Anderson et al., 2006). Cost savings is only recognized if students are actually able to transfer credits. One study found that at least two-thirds of credits must be transferable to recognize savings (Belfield et al., 2017). Of course, the study found "substantial cost savings if students were able to transfer all of their community college credit" (Belfield et al., 2017; Bahr et al., 2017, p. 3).

Besides saving money on course costs, articulation agreements potentially get students into *better paying careers* more quickly. As one author team writes, "taking technical courses earlier in this inverted structure allows students to begin their career in a technical position and then start on the bachelor's degree with the foundation of work experience and financial support" (Zinser & Hanssen, 2006, p. 30). Designed appropriately, articulation agreements can position students so they gain employable knowledge, skills, and abilities in their first two years of coursework, and apply those skills so they can generate income before beginning subsequent educational studies.

Efficiency is a related benefit of articulation agreements. In this context, efficiency refers to saving students time and credits in their academic pathways. Some research shows that articulation agreements increase the likelihood of community college students transferring to a four-year college (LaSota & Zumeta, 2016). Other studies have not found increases in transfer, but have found that those following an articulation agreement were more likely to earn a bachelor's degree than other transfer students (Stern, 2016). Researchers explain this contradiction by pointing out that articulation agreements are not designed to increase transfer rates; instead, they are designed to make transfer more efficient for those who transfer (Roksa & Keith, 2008). As further evidence of this efficiency, research shows that when designed appropriately, transfer articulation pathways are actually easier for students to follow than first-time in college pathways (Grote et al., 2020).

Articulation agreements also help promote *social mobility*. The high percentage of minority and disadvantaged students beginning their higher education studies in community colleges means that the institutions are in a prime position to help individual increase their social status (Wallace & Falla, 2020). Because a higher number of disadvantaged and underrepresented students begin at two-year institutions, when pathways are created between institutions, it is believed that community colleges have the potential to increase representation of minorities in higher paying fields, including STEM (Science, Technology, Engineering, and Math) fields. As a result, a group of scholars recently concluded, "Community colleges are an often overlooked but essential component in the U.S. STEM education system" (National Research Council and National Academy of Engineering, 2012, p. 2). Features such as their "open-access mission, affordable tuition, and locations in almost every community" serve to enhance the role of community colleges in helping minorities and disadvantaged individuals increase their social mobility (Van Noy & Zeidenberg, 2017, p. 1).

Synergism is another benefit of articulation agreements. In this context, the limitations of one higher education institution can be offset by the strengths of others (Fincher et al., 2017). A four-year institution, for instance, might have limited abilities in covering technical knowledge, skills, and abilities for certain careers, while a two-year institution might be unable to address higher level learning, problem solving, and other topics. Combining the two institutions together provides a stronger pathway for students seeking both the technical skills and the higher-level learning requirements to succeed in a cyber career.

Flexibility refers to the different ways that articulation agreements can be used to support student learning. Researchers have noted that students experience transfer differently and that there are many different pathways besides vertical pathways (Taylor & Jain, 2017). These other transfer types include lateral transfers, reverse transfers, reverse credit transfers, swirlers, concurrent enrollment, transient enrollment, and dual credit (Taylor & Giani, 2019; Taylor & Jain, 2017). When designed appropriately, articulation agreements can support each of these types of transfer.

Articulation and policy

It has been argued that articulation agreements be seen as policies (Anderson et al., 2006). Such a perspective helps to formalize the practices and processes guiding the implementation of articulation agreements. States with higher education systems may design these policies at the system level through common core, transferable associates, and common course numbering policies, (Hodara et al., 2017; Spencer, 2019), while those without state systems may leave the development of articulation policies to the purview of educational institutions. Of course, simply having articulation policies does not mean the policies will be implemented effectively (Gross & Goldharber, 2009), that transfer rates will be higher (Anderson et al., 2006), or that students will take advantage of the policies (Hodara et al., 2017). Still, the presence of institutional or statewide policies recognizes that “the responsibility of transfer student success lies not only with the student” (Jackson & Laanan, 2015, p. 144) and promotes statewide efforts to reduce credit loss in transfer situations (Giani, 2019).

For articulation agreement policies to be effective, four things must occur. First, the policies should be clearly written so that all students, advisors, and faculty are able to understand the ramifications of articulation. Second, the policies should be communicated to all parties involved. If students are not aware of the policies, they will not be able to take advantage of the policies (Hodara et al., 2017). Third, the policies must be tailored to the needs of students and the overall purpose of the institutions. There is no template for articulation agreement policies. Finally, linking these last two ideas together, Gross and Goldharber (2009) point out, “all such policies are not the same – so we must account for more than just the presence of the policy when assessing their impact, and account for the mechanisms through which they encourage or facilitate student transfer.”

The faculty role

The articulation agreement literature has also explored the faculty role in the articulation agreement process. Recognizing that faculty control the academic curricula has been hailed as a “guiding principle” for articulation agreements (Ignash & Townsend, 2000, p. 2). This control means that faculty must be involved throughout the articulation agreement process. From helping to craft the agreements to instructing the courses to evaluating and revising the agreements, faculty effort is critical to the success of articulation agreements. A challenge cited in the literature is that faculty from four-year universities may be skeptical of courses taken at two-year universities. Here is how one author described this challenge and its resolution:

A tendency on the part of 4-year institution faculty to question the quality of the course content at 2-year institutions with open admissions policies. The faculty and administration at institutions where transfer is a priority have been able to put these differences aside. More institutions need to consider student needs as central to their mission. (Mosholder & Zirkle, 2007, p. 143)

Experts suggest that faculty work closely with advisors to make sure that credit transfer is seamless. Besides incentivizing faculty to participate in these processes (Shorter, 2015), other aspects of the faculty role include defining transfer as a priority, clarifying the faculty role in advising, establishing disciplinary faculty cohorts between institutions, and promoting an articulation agreement process that values faculty input (Richardson, 1993). 185

Articulation agreement challenges

The mere presence of articulation agreements does not mean that students will succeed (Best & Gehring, 1993). A number of challenges arise that potentially limit the effectiveness of the agreements. These include student barriers, technological issues, concerns about curricula, communication issues, inconsistent applications, and STEM-specific issues. 190

Student barriers arise in as much as students may not be fully aware of the nature of articulation agreements, how they work, or what they are designed to do. Transferring, by itself, can be a difficult process. As one author team notes, at the most basic level, “Students making plans to transfer need to know if schools offer the same financial aid to transfers as they give to freshman, recognize associate degrees, and how credits convey” (Patton, 2017). Students accustomed to the experiences of one institution may experience culture shock when trying to navigate the policies of another institution. Tying together human behavior (of students, advisors, and faculty) and bureaucratic policies creates a potential for miscommunication and misunderstanding. 195

Technological issues may surface with articulation agreements as well. Institutions with different technological infrastructures may have problems interfacing with one another. Such problems will create dilemmas for student, advisors, faculty, and administrators alike. Consider, for example, the inability of students to easily identify how credits will transfer between institutions because of the different types of technology institutions use to record student progress. The technological infrastructure is typically designed to keep students at an institution rather than to help students transition between institutions. 200 205

Curriculum issues also arise when developing articulation agreements. On one level, concern about curriculum quality arises when faculty at the four-year institution question whether the two-year institution’s courses are meeting the learning outcomes needed for success in the four-year institution (Regier, 2016). This may be a particular concern for STEM majors where the community college courses are building block courses for upper level courses (Regier, 2016). On another level, differences in curricula across community colleges may make it harder for four-year institutions to identify a common pathway for all students (Fincher et al., 2014). 210

Communication issues are concerned with the lack of attention given to articulation agreements. Describing concerns about how visible articulation agreements are, one author team points to failures to describe articulation agreements as pathways, underreporting of the agreements, treating the agreements as afterthoughts, and including negative connotations about transfer in catalogs as communication challenges that come up with articulation agreements (Fincher et al., 2014). Even the phrase *articulation agreement* is not a part of the lexicon for the typical student or their families. If institutions fail to actively communicate about the agreements, it is unlikely that students will actually use the agreements. As well, research shows that the vast majority of community college students do not fully understand the content of articulation agreements (Taylor, 2019). 215 220

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Somewhat related, *inconsistent application of articulation agreements* and lack of consistent standards in creating articulation agreements can create problems for students (Best & Gehring, 1993). The result of these processes is that students end up wasting time and resources in their transfer efforts. Describing the confusion that arises with articulation agreements, one state official told a research team the following: 225

I'm surprised that students don't come to [the state capital] with torches and pitchforks. It's an incredible thing. Half of them say every year that their goal is to transfer and they have to struggle with the process. Transfer students tend to be older, have more family responsibilities, they are working people. You'd think that they would come here with shotgun in hand protesting the process, but they haven't. Nonetheless, it is a serious policy goal: These students have the right to know exactly what behaviors are expected of them and, if they meet those behaviors, then they have the right to transfer. (Welsh & Kjorlien, 2001, p. 330) 230

STEM-specific issues also surface with articulation agreements. For example, the higher level of math required for STEM majors may present challenges if students are not aware of those expectations. Also, STEM majors at community colleges will have close contact with their faculty, but once they transfer to a four-year university their level of faculty contact may diminish (Jackson & Laanan, 2015). In addition, the heterogeneity of STEM fields means that each STEM area may need specific attention at the two-year and four-year university (Wang, 2016). In other words, it is difficult to align STEM at a two-year institution with STEM at a four-year college. A more reasonable approach is to align specific programs within STEM at the lower and upper level institutions. 235 240

A related STEM issue in articulation agreements is that some students, technical majors in particular, might be dissuaded from transferring due to community college procedures (Fincher et al., 2017). The source of dissuasion may be the difficulty of creating an adequate foundation for certain four-year majors within a two-year timeframe focused on specific skills. Said one expert: "One of the more challenging issues is how to provide a dual foundation in academics and occupational skills so that students can enter the technical workforce while leaving open their option to attain a bachelor's degree" (Zinser & Hanssen, 2006, p. 28). 245

Such a problem may be particularly salient for new careers in cybersecurity. Quick technological changes make it harder to keep up with the technical skills required for new cybersecurity jobs. Drawing attention to the ever-changing knowledge base, Hoffman et al. (2012) conclude: 250

This dynamic nature suggests that long-term responses must be flexible to accommodate these changes. Rather than a single, iron-clad solution for everyone, concerned employers, academic leaders, and government officials must look to construct a road map to provide flexibility in terms of content, delivery mechanism, and education financing for cybersecurity students. At the same time, they must incorporate nontraditional approaches to education and training alongside university-delivered courses. These approaches should include . . . well-designed two-year community college curricula that either produce strong, desired skills for market-ready workers or articulate seamlessly to four-year baccalaureate programs [emphasis added]. (p. 38) 255

With cybersecurity programs, in particular, 2 + 2 articulated cybersecurity programs between community colleges and four-year schools have been applauded based on the fact that "there are not enough cybersecurity students in the post-secondary pipeline to defend and protect our nation's critical information networks" (Hawthorne, 2014, p. 33). At the same time, it may be harder to transfer cybersecurity coursework than coursework from other programs. In the words of one group of experts, "Many associate degree courses in IA [information assurance/cybersecurity], often taken toward accomplishing industry-based certifications do not easily transfer into baccalaureate programs. Guidelines and standards for IA [information assurance/cybersecurity] education will likely facilitate this much needed articulation" (Cooper et al., 2009, p. 62). 260 265

As one author team has noted, "Providing students with unambiguous direction to navigate the STEM pipeline in an efficient manner will be critical to fully realizing the potential of community colleges" (Bahr et al., 2017, p. 468). Another author team wrote, 270

In institutions that have implemented guided pathways reforms, academic programs are clearly mapped out by faculty to create educationally coherent pathways with clearly defined learning outcomes that are aligned with requirements for further education and, in occupational programs, for career advancement. (Jenkins & Cho, 2014, p. 2) 275

Faculty and higher education administrators must be thoughtful about the strategies used the versatility and strength of cybersecurity pathways. Experts have suggested that "exemplary" pathways programs are those that:

- Align curricula with clear learning goals, as well as recognized academic/occupational standards; 280
- Address important individual, economic, and societal needs;
- Offer innovative program design that contributes to educational excellence for all learners;
- Engage in systematic evaluation processes that provide evidence of program effectiveness and student outcomes;
- Contain programmatic elements that can be implemented, adopted, or adapted to other ... 285
settings (Makela et al., 2012, p. 9).

The problem is that so few programs have implemented guided pathways reforms for cybersecurity programs. As a result, limited understanding exists regarding the best way to align applied cybersecurity degrees offered in community colleges with four-year degrees offered in colleges and universities. Because the authors have participated in such an effort, we are able to use our experiences to shed some light on effective strategies to build pathways between cybersecurity programs with seemingly different types of curricula. 290

Articulation agreement process

Old Dominion University (ODU) has developed six cybersecurity articulation agreements with community colleges in Virginia. In 2016, ODU began to develop articulation agreements aligning community college coursework with the bachelor's program in cybersecurity. To date, ODU developed articulation agreements with six community colleges: Germanna, Lord Fairfax, Northern Virginia, Piedmont, Thomas Nelson, and Tidewater Community College (Old Dominion University [ODU], 2020). After reviewing the articulation agreement process in general, specific attention will be given to how the process was used to develop these agreements. 295

Figure 1 shows the process used to develop articulation agreements at Old Dominion University. The process typically begins with a request to create an articulation agreement. The request can come either from the community college or the university and it typically focuses on creating a specific program pathway. In this particular situation, faculty from Tidewater Community College and Thomas Nelson Community College were working with Old Dominion University faculty on the Regional Alliances for Multi-Stakeholder Partnerships (RAMPS) project funded by the National Institute for Standards and Technology (Santos et al., 2020). One facet of the RAMPS project called for the creation of an articulation agreement between the community colleges and Old Dominion University. 300

Following the process outlined in Figure 1, faculty and advisors by Old Dominion University and Tidewater Community College began to meet to review course requirements in their respective programs. Following the analysis step, the next stage was to create a sample course outline that did not provide any specific course concessions by either institution. This sample course outline showed that if students completed the AAS at TCC and then went to ODU for a bachelor's in cybersecurity, they would need to take 165 credit hours at the two institutions. Stakeholders then consulted and negotiated ways to get the agreement closer to 120 credit hours. Eventually, advisors, working with faculty directors, developed an agreement that landed on 121 hours between the two degrees. 305 315

Moving to the third stage, participants took time to review the agreement to make sure that all learning outcomes between the two programs would be met through the articulation agreement. This involved consultation between faculty in the respective programs, advisors in the Transfer Initiatives unit at Old Dominion University, and administrators at both institutions. Once everyone was in agreement, a date was set to sign the agreements. 320

The final stage, approval, was carried out with a signing ceremony. As will be shown below, the signing process is typically perfunctory. In this case, we used the signing ceremony to market and begin the implementation of the articulation agreement. Once the agreement with TCC was created, we then began to develop similar agreements with the other community colleges. Because we had 325

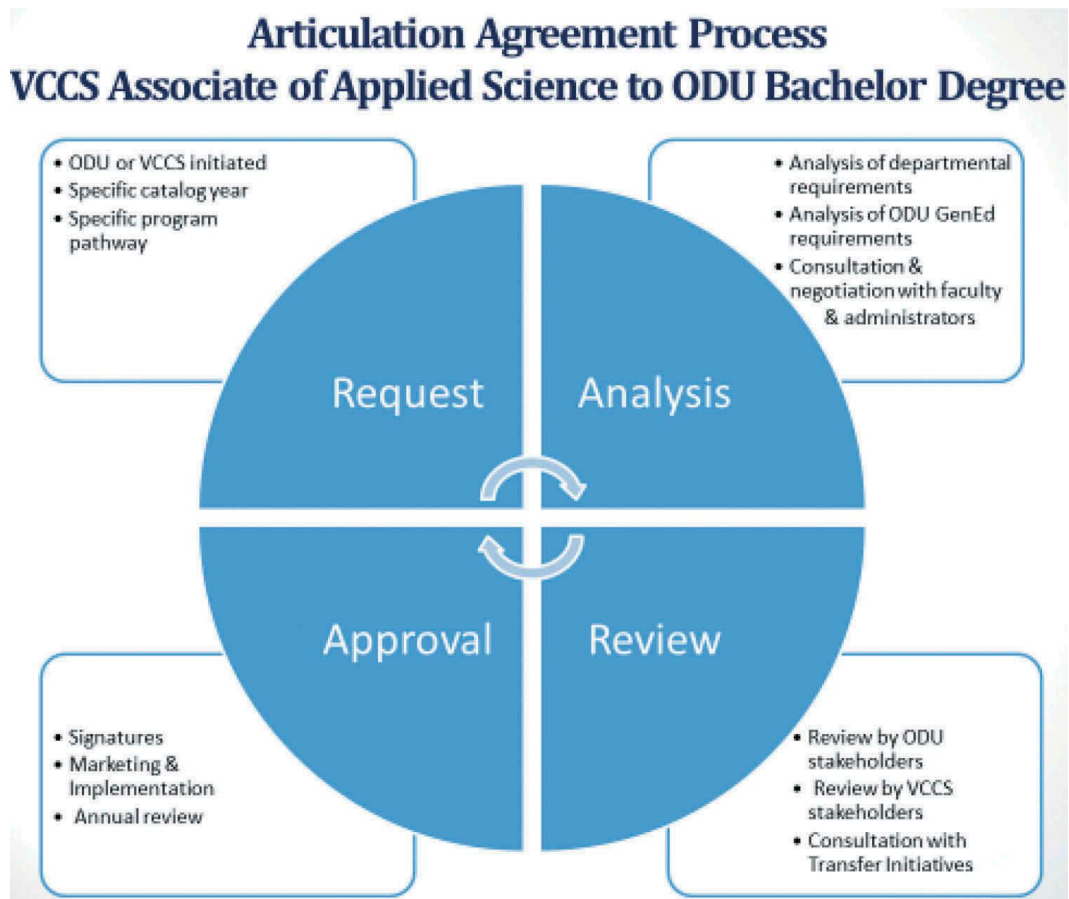


Figure 1. Articulation agreement process at Old Dominion University.

a template for the agreement in place, developing the subsequent agreements went more quickly. In the next section, we expand on our specific experiences with the articulation agreement process.

Authors' experiences with cybersecurity articulation process

Research instrument and data sampling

Using an autobiographical research case study/researcher as participant methodology, the coauthors assessed their experiences with the articulation agreement process. After the cybersecurity articulation agreements were signed and implemented, the authors reviewed the processes guiding the development of the agreements. As part of this review, the lead author asked the coauthors to respond to the following five questions to the best of their abilities:

- (1) *What works well in the articulation agreements for you and your students?*
- (2) *Are there areas where we can make the agreements better?*
- (3) *What have been some obstacles in creating the agreements?*
- (4) *What do you see as the advantages in having the agreements in place?*
- (5) *What advice would you give other institutions developing similar agreements?*

These questions formed the basis of the case study. Where necessary, some of the coauthors discussed the questions with their colleagues and sought feedback from them to inform the autobiographical case study. In those circumstances, the coauthors' colleagues were not actually research subjects but

were providing the coauthors with general information that could be used as part of the case study. After receiving the feedback from the coauthors, the lead author used manifest and latent content analysis to identify themes and patterns that were part of the processes.

345

What worked

Our process was bolstered by seven areas of success: clear communication, guarantees to students, designated physical space, virtual space, flexible meeting space, accuracy, and simplicity. *Clear communication* was beneficial in that participants between institutions maintained open communication channels between all parties involved. Faculty, advisors, and administrators were able to communicate directly with their counterparts at their institution and the other institutions. These communication patterns were studied by an educational doctoral student for his dissertation which explored power dynamics during the articulation agreement process (Moore, 2018). Perhaps the most important part of the communication included negotiating and revising courses that would be included in the agreements.

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Guarantees to students also strengthened the process. Students completing the courses listed on the articulation agreement and receiving the Associates of Applied Sciences are guaranteed admission to Old Dominion University and guaranteed that they can complete the BS degree in cybersecurity in 120 hours. The guarantee includes clear stipulations that students should take specific courses at the community college. Also built into the guarantee is the award of credit for demonstration of competency (as determined by certifications). The clarity of the guarantees to students helps advisors, faculty, and administrators at each participating institution describe the articulation agreements to students. Such a guarantee leverages research showing that students who transfer with a transferable associate's degree are more likely to graduate with a bachelor's degree than those who do not transfer with the associate's degree (Umbach et al., 2019).

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Designated physical space also helped strengthen the articulation agreement process. Three types of space were particularly important: space for students, virtual space, and meeting space. Regarding space for students, where feasible, Old Dominion University created transfer centers in locations near the community colleges and on the University's main campus, with the centers providing a dedicated space for transfer students.

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Virtual space was also helpful in the process. Three types of virtual space supported our efforts. First, for those institutions where travel was not feasible, agreements were developed through e-mail. Not coincidentally, in these situations, the agreements were done after a template for the agreements had already been created with the community colleges near Old Dominion University. We also had the benefit of a virtual lab that was made available to community college students and though the lab was not often used, it signaled a willingness to collaborate. Third, we held virtual meetings to maintain communications between Old Dominion University and Northern Virginia Community College.

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Flexible meeting space was also paramount to our efforts. When holding meetings, a conscious effort was made to move meetings between the community college location and the four-year institution. Here again, the intent was to send a message about the openness to collaboration. As well, when three of the agreements were signed, representatives from Old Dominion University (including the president, provost, vice provost, faculty, and advisors) traveled to the respective community college for a signing ceremony. Because students would be starting at the communication college, symbolically it made sense to start the agreement signing at the community college.

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Accuracy was another important feature of our cybersecurity articulation agreement process. Since the agreements were signed, participants have reviewed them annually to make sure that the courses were still accurate. In addition, faculty agreed to provide early notification of changes at their home institution so that the partner institution would have time to understand the ramifications of those changes.

390

Simplicity was a final strength of the agreements. Of course, simplicity does not refer to the courses, but to the specificity of the agreements and instructions. Having courses specifically identified with the students taking the entire Associates of Applied Science with specific expectations included helped all parties involved. In the words of one of our colleagues, “it’s better if it stays that way always.”

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Advantages identified from the articulation agreements

Given the robust amount of literature promoting articulation agreements, it should not be surprising that our experiences identified many advantages with the agreements. These advantages included: necessity, time and money, political will, student responsiveness and institutional clarity. In terms of necessity, three fundamental points supported the need for developing the cybersecurity articulation agreements. First, as noted above, the high demand for careers in cybersecurity warrants college-educated graduates. Virginia, in particular, has the highest number of cybersecurity job vacancies per square mile (Cyberseek US, 2020). Second, the nature of requirements in the applied and bachelor’s degree meant that no student with an applied degree would actually seek a bachelor’s degree unless a pathway existed. Third, and somewhat related, an earlier survey we conducted that was funded by the National Institute for Standards and Technology found that employers wanted students who had both technical skills and soft skills. In other words, employers essentially told us they needed students with the specific skills that would come out of an articulated AAS/BS degree pathway.

Second, the cybersecurity articulation agreement saves students *time and money*. If the articulation agreement were not created, students would have needed 165 credit hours to earn both the applied and bachelor’s degree. The creation of the articulation agreement saved students at least a year and a half in college and approximately 16,500 USD in tuition and textbook costs. As well, by saving time, the agreement provided students the opportunity to enter the workforce more quickly.

Another advantage of the cybersecurity articulation agreement is that it responds to *political will* on two fronts: by reducing the costs of a degree and creating cybersecurity graduates. Recognizing the political value of the agreements, Governor Terry McAuliffe spoke at a ceremony when one of the agreements was signed and the Virginia Secretary of Technology spoke at another signing ceremony (Buddlemeyer et al., 2017). Presidents and vice presidents from participating institutions were also in attendance. Typically, articulation agreements are signed in an isolated office as a matter of routine office duties. In this case, the value of having faculty and advisors participate in an event with high level political and academic representatives cannot be understated.

Student responsiveness is another advantage of the cybersecurity articulation agreement. The agreements were designed principally to help students earn their degrees. The agreements were designed to show students exactly what they needed to earn the applied and bachelor’s degrees. In doing so, this made it easier for students to transfer. The fact that the agreements are student-focused allowed the institutions to promote the agreements as a recruiting tool.

Institutional clarity is a final advantage of the cybersecurity articulation agreement. In this context, the process provided stakeholders the opportunity to get to know one another’s institutions and become more familiar with the other institution’s processes and expectations. This also created a scenario where students could learn about the expectations and processes of different institutions. As one faculty member shared, “Too much information about the expectations of transfer from one institution to another has been mysterious to students.” In addressing these advantages, it is important to draw attention to the way that the advantages identified in the case study compare to the advantages highlighted in the literature review above. Table 1 provides a thematic comparison between our experiences and those identified in prior literature. As shown in the table, our experiences support the suggestions made in the literature about the value of articulation agreements.

Table 1. Comparison of articulation agreement advantages identified in prior literature and our experiences.

Theme from Prior Literature	Research Related to the Theme	Our Experiences as they Relate to the Theme
Affordability	Anderson et al., 2006; Lipscomb, 2019 Patton, 2017	Students save \$16,500 through following the articulation agreement
Better paying jobs	Zinser & Hanssen, 2006	While some cybersecurity jobs can be obtained without a Bachelor's degree, one review of roughly 95,000 cybersecurity job openings found that more than 85% required a Bachelor's degree. The articulation agreement provides community college students access to a Bachelor's degree (Slyter, 2019).
Efficiency	Grote et al., 2020 LaSota & Zumeta, 2016 Stern, 2016 Roksa & Keith, 2008	The cybersecurity articulation agreements provide for an efficient use of credits, with students saving up to 45–50 credits they would have to take if the agreements did not exist.
Enhanced Social Mobility	Wallace & Falla, 2020 National Research Council and National Academy of Engineering, 2012 Van Noy & Zeidenberg, 2017	At ODU, the characteristics of the cybersecurity students suggest that the program promotes social mobility: 44% of the students are African American, 38% are Pell-eligible, and 33% are first-generation students.
Synergism	Fincher et al., 2017	A review of the articulation agreements suggest that the community college students have a much stronger technological foundation than do those students who did not transfer from a community college.
Flexibility	Taylor & Giani, 2019	Advisors and faculty from the respective units have initiated efforts to develop reverse transfer protocol allowing ODU transfer students who did not earn a cybersecurity associate's degree to transfer ODU credits back to the community college to earn an associate's degree on their path to a Bachelor's degree.

Obstacles encountered: results from our case study

Despite these areas of strength, certain challenges arose during the development of the cybersecurity articulation agreements. Generally speaking, these challenges focused on the interdisciplinary nature of cybersecurity, programmatic changes, the nature of applied degrees, meeting times, and course substitutions. Regarding the *interdisciplinary nature of cybersecurity*, the upper level cybersecurity courses at ODU come from seven different academic programs: computer science, information technology, computer engineering, criminal justice, political science, philosophy, and cybersecurity. The cybersecurity program and courses with a cybersecurity prefix are administered by an interdisciplinary center. All other courses are controlled by the home academic department. What this means is that rather than working with one department at ODU to articulate the community college coursework, multiple departments had to be involved. This, in and of itself, created more work than might be found in traditional agreements.

Programmatic changes also surfaced as challenges. While the cybersecurity program itself would be articulated and consistently applied per the strong relationships between the cybersecurity faculty at participating institutions, changes in the courses from other programs contributing to the interdisciplinary degree (information technology and computer engineering for instance) created a ripple effect. For example, if information technology at Old Dominion University changed its prerequisites for upper level courses, this would make it necessary for faculty at participating institutions to review the agreements to see if the change impacted the ability of students to take the upper level courses. More times than not, the changes had no impact. But still, this added an extra layer of complexity to the process. In the words of one community college faculty member, “the various departments at each institution make for constant moving targets which is a challenge.”

The *nature of applied degrees* also made the articulation process more difficult. Specifically, as has been noted elsewhere, applied degrees typically are not created as transfer degrees (D'Amico et al., 2020). Instead, their intent typically is to give graduates applied skills that can be used to immediately

enter the workforce. Taking the general education requirements after the degree has been earned may seem counterintuitive. In addition, the math requirements for applied degrees at the community college was lower than what would be needed for upper level cybersecurity coursework, so additional math courses had to be built into the agreement. As well, it is very difficult to create a co-enrollment experience (which is seen as the ideal transfer model by many) with AAS degrees. 465

Meeting times were also challenging. Even when faculty and advisors were willing to switch the location of meetings (see above) the fact remains that it was difficult to find time to meet. Institutions have different teaching schedules and varying semester schedules. Faculty have different schedules than advisors. Finding time that matches institutional and individual schedules is no easy task. It is important to note that such an obstacle arises in all types of articulation agreement discussions. 470

Course substitutions were also problematic. If a native student wants to substitute a class in their curricula, this can be done electronically. For transfer students, it is much more difficult for students at a community college to substitute a class in an articulation agreement. The substitutions are a manual process after a student transfer. As a result, more time than usual was spent on course substitutions and some students likely chose not to even seek the substitutions because of the bureaucratic layer. 475

Opportunities for improvement

The obstacles we confronted combined with the advantages that surfaced helped us to identify several opportunities for improvement in subsequent cybersecurity articulation agreements. These opportunities include tracking, marketing, and inter-institutional curriculum mapping. *Tracking* students in various parts of the cybersecurity pathway is an opportunity to better serve students in the process. We don't know how many students are in the pathway or where they are in the pathway until the students either graduate or file an intent to enroll. Lacking awareness about students makes it impossible to serve them. Our plan is to build better connections between our respective admissions, advising, and institutional effectiveness offices so students can be more easily tracked. Strides have been made in reverse transfer discussions where the four-year institution identifies transfer students who might be able to transfer credit back from the four-year institution to the two-year institution in order to earn a two-year degree. These tracking processes will be evaluated and assessed by the Office of Institutional Effectiveness and Assessment at Old Dominion University. 480 485 490

In addition, our process can be improved with better marketing of the cybersecurity articulation agreements. Five groups, in particular, would benefit from targeted marketing efforts. First, marketing to potential students (included high school students and degree completers) would have helped increase awareness of the agreements. Second, students currently enrolled in community college programs could be made more aware of the agreements. Third, faculty at all participating institutions would find value in understanding how their curricula aligns with curricula taught by other faculty. Fourth, academic advisors would be better able to advise about the agreements if they are fully aware of the presence of the agreements, their details, and their ramifications. Finally, employers would be more open to hiring graduates from these programs if they are aware about the pedagogical value of the agreements. 495 500

Inter-institutional curriculum mapping would also strengthen our cybersecurity articulation agreements. Each home institution created their degrees and mapped their curricula within their own institution. Combining the degrees may unintentionally ignore certain knowledge, skills, and abilities. Describing this potential dilemma, one faculty member told us:

I would like to see something like a crosswalk document (matrix) of KSAs (knowledge, skills, and abilities) based on the NICE Framework demonstrating the intent of the coursework as it relates to industry needs. This may be beneficial to students who may not be sure what kind of jobs they are training for (I often hear this from students), and employers who may be asking about the kind of training students receive. This will require greater and more specific interaction between advisory boards and college personnel, but that is the direction we are headed towards. It may present a more complete picture of industry needs and wants if there is a comparison between the two participating institutions' advisory meeting notes. 505 510

Future recommendations for articulation agreements

Taking this a step further and tying together what we learned from our experiences with the academic literature on articulation agreements, a number of recommendations can be identified to improve the articulation process. Suggestions found in the literature center around culture, evaluation, flexibility, communication, collaboration, and alignment. Regarding *culture*, several experts have stressed the importance of developing a culture that embraces transfer students (Fincher et al., 2017; Jain et al., 2011; Yang, 2018). Yang et al. (2018) specifically call for a “culture of transfer” (p. 40), while Jain et al. (2011) take it a step further and stress the value of a “transfer receptive culture” (p. 252). The underlying implication is that valuing transfer processes is not enough. Instead, institutions, particularly four-year institutions, must value receiving transfer students. Building on this, if institutions value receiving those students, they would be likely to develop and implement policies and practices favorable to incoming transfer students. From our own experiences, it seems that the transfer receptive culture at Old Dominion University is both robust and pervasive. But, an institutional culture is not enough. It is a necessary condition, but not a sufficient condition to produce successful articulations. Instead, at the unit level, faculty and unit level administrators must both embrace and promote the culture of transfer to others in their respective units.

The importance of *evaluation* is also highlighted in the articulation agreement literature. The mere presence of articulation agreements should not be seen as a success. Rather, it has been suggested that evaluations should be data driven (Ignash & Townsend, 2000). Ideally, the evaluation process should be built into the development of the agreements from the start (Hope, 2016). Recommended data sources to assess articulation agreements include administrative records and surveys of students to assess their transfer motivations over time (Wang, 2016). The current article shows that case studies can also be a part of the articulation agreement evaluation. In addition, the need to focus the evaluation at the unit level, rather than the college or institution level is also demonstrated through our case study.

Flexibility has also been recommended as an important component of developing articulation agreements. On one level, faculty, staff, and advisors will need to be flexible and not expect courses to automatically match in entirety. On another level, participants must be willing to change or alter the agreements when necessary. Somewhat related, while articulation agreements typically align lower level degrees with upper level degrees, some have called for flexibility and recommend accommodating students without degrees (Ignash & Townsend, 2000). While our current arrangements do not allow for this level of flexibility, our faculty were most certainly flexible in determining how to align course credits.

Communication has also been highlighted as an important facet of articulation agreements. Faculty and advisors need to communicate between institutions about curricula, course revisions, challenges transfer students are facing, and other topics of mutual interest. In addition, students need to know about the availability of the agreements and the benefits of the agreements. One author team suggests the transfer issues be given appropriate attention in catalogs and that institutions should “make articulation a theme that is woven through the college website” (Fincher et al., 2014, p. 691). It has also been suggested that part of the communication strategy focus getting students to pick their majors early on, otherwise the articulation agreements may have limited value for students (Hodara et al., 2017). Hodara and colleagues recommend advising high school students about transfer so that they are thinking about it when enrolled in a two-year institution. In a similar vein, others have recommended a long-term perspective that sees articulation agreements as extending from high school to community colleges to four-year institutions to employers and industry (Just & Adams, 1997).

Not surprisingly, *collaboration* has also been identified as a key ingredient for articulation agreements. Clearly, to be effective faculty must collaborate between institutions on curriculum development and curriculum revisions (Hope, 2016; Zinser & Hanssen, 2006). In addition, it is recommended that faculty and staff from the multiple institutions work together to create the evaluation plan and assess the success of the agreements (Hope, 2016). The importance of

commitment to collaboration cannot be understated. In the words of one author team, “collaboration ... between institutions bolsters critical understanding and supports transfer success” (Yang et al., 2018, p. 40). Collaboration helps promote equity ideals by providing all students access to a four-year degree (Ocean et al., 2020). As part of the collaboration efforts, it is critical that diverse and inclusive viewpoints from advisors, faculty, and administrators be included in the process. For us, we had no less than eight individuals representing each area participate in the development of each agreement. 565

Somewhat related, in addition to collaboration it has been suggested that attention be given to *alignment between institutions, alignment within institutions, and alignment to educational purpose*. 570 Regarding alignment between institutions, it is recommended that participating institutions align transfer processes to allow for seamless movement between institutions. Regarding alignment within institutions, it has been suggested that articulation agreements align with curricula, advising, data analysis processes, student learning outcomes, and the institution’s strategic goals (Hope, 2016). Regarding alignment to purpose, experts recommend that the purpose of articulation be aligned to the purpose of education as defined in the participating institutions’ purposes (Mosholder & Zirkle, 2007). 575 The purpose of articulation should not be enrollment growth. Instead, the purpose should be tied to the overall purpose of the academic programs and institutions. In our case, the aligned purpose statement might be something like this: *Our cybersecurity articulation agreement provides learners a cost-effective pathway to a career that will enhance their social mobility while meeting the needs of the community*. 580

While aligning the purpose of articulation agreements with broader purposes, it is important to consider the multi-faceted nature of articulation agreements. As shown above, articulation agreements are policies (e.g., they are written standards used to guide behavior). Articulation agreements are also processes that should be seen as dynamic and flexible rather than static and isolated events. In addition to being policies and processes, articulation agreements are tools that are designed to make it easier to understand how courses and programs transfer between institutions. In serving each of these roles, articulation agreements are also pathways or, as noted elsewhere, roadmaps that help students move from one point in their life to another point. 585

In closing, it is important to note that articulation agreements are not a panacea. There is growing consensus that articulation agreements “should be considered only a small part of a more comprehensive effort that involves institution – and student-level efforts to improve transfer opportunities” (Gross & Goldharber, 2009, p. 29). While a small part of these efforts, they can be a critical component for students looking to save money and time in their pursuit of higher education. The cybersecurity articulation agreement, in particular, has been critical to help students on the pathway to their degrees. 590 595

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