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Examining Student Experiences Related to Transfer from Two-Year Technical Colleges to Engineering and Computer Science Degree Programs at a Four-Year Institution

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Abstract

In this paper, we explore issues related to student transfer from two-year technical colleges to four-year institutions in the context of SPECTRA, an NSF Scholarships in STEM (S-STEM) project (Award#1834081) led by Clemson University in Upstate South Carolina. The program's purpose is to provide financial support to low-income transfer students who intend to transfer from South Carolina's two-year technical colleges into a four-year computing or engineering degree at Clemson. The program is currently in its fourth year of implementation. In the first two years, we suffered setbacks in student recruitment due partly to the impact of the COVID-19 pandemic; however, our current participant numbers are increasing. We collected data from the existing participants regarding their experiences with the transfer process, which helped us better understand how the SPECTRA program has impacted them academically, socially, and financially. The initial findings from the SPECTRA cohorts suggest that students' main struggles in their transition to Clemson revolve around poor time management tactics and feeling unprepared for some of the courses they are taking within their degree program. Their difficulties may be due either to a lack of preparedness for previous classes (stemming from their technical college or from Clemson itself) or to not fully understanding what would be asked of them within the course before registration. In addition, they share struggles relating to their Clemson professors. Positive impacts come from their experience at Clemson and their direct SPECTRA involvement. Examples of these benefits include building skills, participating in undergraduate research, creating and having a community with fellow students, and developing their identities as engineers and computer scientists. Undergraduate research is a highly valued aspect of the SPECTRA program. The students work closely with graduate students, known as the ACE Fellows, for their research. The students believe these ACE Fellows act as mentors, who they find more approachable than professors, and valuable resources to them in their education journey and development as engineers. Another value of the program is the scholarship opportunity that SPECTRA provides. Students believe the funding they receive has significantly impacted their education. Some state that they would not be able to attend Clemson had they not been provided scholarships. Others have avoided picking up second jobs, allowing them to focus more energy on succeeding in their programs. In our ongoing work, we explore these initial findings and assess changes implemented from student feedback to improve the program. We seek to understand better the long-term effects the program may have on their students, including graduation rates and pathways to future careers.

Introduction

Technical or community colleges provide one pathway through which engineering students may enter the field. Such pathways are beneficial for colleges and universities to take advantage of, as they not only provide an additional resource for students but also tend to be the starting point for many underrepresented student populations such as first-generation, underrepresented minority students, women, veterans, and non-traditional students [1][2]. Smith-Doerr et al. [3] explain four main reasons the engineering workforce can benefit from additional diversity. The first is

that all people should be treated equitably and be given a fair chance to pursue their goals. Secondly, there is an economic need for more workers and diverse populations to represent a new pool of people to join the workforce. Thirdly, diversity brings in new ideas and experiences that can allow the field to grow and evolve in ways that it may not have before. Fourth, to solve problems and make improvements, many people must have a wider understanding and involvement to cause significant impacts on society.

Students may have any number of reasons for choosing to start their engineering pathway at the community or technical college level. Some reasoning for this may include proximity to their hometown, allowing some students to remain close to dependent family members or their places of work [4]. There are often also financial reasons that a student may wish to start at a community college, as the cost of tuition is typically much less than that of a four-year degree program [5][6].

While a technical college may provide a good foundation for beginning a four-year program, students who transfer into these programs may experience more barriers to their success than their peers who started at the four-year program. One of these barriers is transfer shock, in which the student experiences a transitional decline in GPA, causing them to fear for their success and potentially drop the program altogether [7][8]. They may also continue to face financial strain as the cost of attendance likely increased from their previous technical college [9]. Students may lose credit hours during the transfer process due to their four-year university requirements. This can set students back as they may have completed coursework that will not set them forward in their new program [6]. A large factor in transfer student difficulties is also a lack of social support in their new environment [2][9][10].

Several programs have been put in place by four-year colleges and universities across the country to ease the struggles that transfer students face during their transition. Common findings amongst these types of programs include but are not limited to finding benefits to students through resources such as scholarships or financial relief [5][11][12], benefits of having undergraduate research experiences [1][5][11], and construction of a community or support system [7][5][12].

A common theme amongst many transfer programs is that they allow students to participate in undergraduate research experiences. It can allow students to build connections with peers and network with faculty or other researchers, as well as provide them with the experience of putting their skills to work in the laboratory setting [1][5]. In some instances, the participation of undergraduate students in research projects leads to a higher percentage of graduating students than those who did not participate [11].

Feeling connected and building a community is also a common finding among the programs. Transfer students may feel particularly alone as they begin their new programs [10]. Some students, such as women of color, may particularly feel the effects of isolation and disconnection [1]. Encouraging students to participate in school activities, groups, clubs, or other social events, may lead to greater success in their classes and programs [7]. By connecting with their peers, students may also begin to build and develop their identities as engineers [12].

Program Overview

The SPECTRA program is in partnership with Clemson University and state technical colleges. The program's overarching aim is to assist low-income technical college students as they transfer to Clemson University in hopes of increasing student recruitment, retention, academic success, and graduation rates for technical college transfer students.

There are 16 schools within the South Carolina technical college system, and SPECTRA works directly with two of them (Spartanburg Community College and Trident Technical College). About 13% of college-aged people (18-25) in the US live below the poverty line [13], making technical college a more financially viable option to gain a degree. In South Carolina, technical college tuition has recently been waived due to the effects of COVID-19; however, before this event, the highest cost of tuition at an SC technical college was only $4,752 as compared to a semester's tuition at Clemson, which is currently $15,120. While not necessarily entirely impacted by tuition, the SC community college system currently enrolls about 38% of the state's student population. Despite this high percentage, many students may choose to transfer to Clemson, and the number of students choosing to transfer has been increasing over recent years.

The goals of SPECTRA are as follows:

(1) to provide scholarship opportunities to low-income students who wish to pursue engineering or computing at Clemson

(2) to build cohorts of transfer students to support their transition into Clemson University while also allowing for the ACE fellows program to aid in the training and practice of PhD candidates who wish to pursue careers in academia

(3) to assess its progress both internally and externally to assist the transfer students best and improve the program

The ACE Fellows aspect is part of the SPECTRA program. It involves taking PhD students who are interested in teaching but may not yet have had the chance to pursue it and allowing them to work with the students by teaching classes at the community colleges and hosting research projects for the SPECTRA students to participate in.

Methods

The overarching educational research integrated into the SPECTRA project focuses on various themes with a range of participants on the project, including graduate students, staff, and faculty. As a design-based implementation, we use the research to guide development and illuminate important emergent evidence in the ongoing intervention. The work we highlight in this paper focuses on the transfer student participants at the center of the project. Although we are still implementing this funded research, the findings we share here are an early summation of formative data collection and analysis iterations.

We implemented data collection in three parts, with the first two being complementary engagements with undergraduate scholars. In the first part, we gave the students participating in the project a Qualtrics survey which targeted general aspects of their experience until that point. The surveys were used to gauge questions and occasionally create unique questions to the individual during an interview. Additionally, the ACE fellows were interviewed about their perceptions and experiences working with the students.

The initial data collection was done via a Qualtrics survey. The students were asked to complete the survey at the start and end of the semester. There were two versions of the survey given, one was targeted toward incoming students, and one was targeting returning students to the program. Questions within the survey were generally multiple choice to judge how prepared students felt with their courses. There were also several open-ended questions asking for more specifics about their transfer experience.

In the second part, after collecting survey data each semester, we asked the students to participate in a mid-semester interview session with the educational researchers. Where applicable, the data collected in the survey were used to personalize the interviews for students to clarify or expand upon their answers. Interview questions included probes at their experiences upon transferring to Clemson, their cohort and their interactions with other SPECTRA students, their mathematical and academic experiences, and any changes they would like to see made to improve their experience. Interviews were conducted over Zoom, as during the time that the initial interviews were to be held, the university was undergoing restrictions due to the COVID-19 pandemic. The semi-structured interviews typically consisted of one student talking with one or two educational researchers.

The student interviews were then transcribed and uploaded onto Taguette, free software used for coding. Researchers did an initial coding pass with a pre-established codebook and made a note of new emerging codes. After the initial coding pass, the codes were separated and divided into subcodes. These subcodes were analyzed, and the findings were discussed amongst the research team. Subcodes were further connected to find overlying themes amongst the data and then discussed to determine what importance could be pulled from the data.

The third part of data collection and analysis focused on the ACE fellows, the graduate students who work with undergraduate scholars. In addition to interviewing the students in the SPECTRA program, the ACE fellows were also interviewed to further understand the students' experience from the perspective of the graduate students who are helping to mentor the undergraduates. ACE fellow interviews were conducted via Zoom and held with one ACE fellow and two educational researchers. The interview was semi-structured and not as in-depth or detailed as the interviews help with students. Questions asked to the ACE fellows intended to find the ACE fellows' perceptions on the purpose of the program, the importance of the program for the students and themselves, and how the program could be improved upon in the future. This information was not coded but instead used to compare back to data and codes that had been developed from the SPECTRA student interviews.

Findings

Student Difficulties

As previously discussed, transfer students often face difficulties transitioning to a new school. The interview data from the SPECTRA cohort suggests that student difficulties mainly circulate around problems with time management and feelings of unpreparedness.

Some students found that their transition to Clemson caused them to dedicate much of their time to coursework. They find that their classes may require large amounts of homework or study. Students may be more likely to prioritize classwork than SPECTRA activities and engagements. The students want to do well (mainly by earning passing grades), and some interviews suggest that the need to do well in courses supersedes students' needs and desires to do other activities. In some cases, the time they spend doing schoolwork overshadows basic activities such as laundry, sleeping, or cooking meals. Students may feel additional struggles in time management due to external commitments, such as jobs (that some must have to help pay expenses) or the long commute to the Clemson campus.

Example quotes from students highlighting *Student Difficulties* in time management
"I am learning it, but it's like when I learn one thing I'll start falling behind in this class. When I catch up in this one I fall behind in this one. Catch up in this one. And then it's just like a cycle. It's just. I think it's just my time management."
"Versus during school, I barely have time to even like do simple necessity is like doing laundry"
"I graduated with a 3.95 or something like that I was really proud and I came in and I said hey I want to, I want to get the full Clemson experience. But I'm also I'm taking the bus two hours every day and I'm transferring to a new school I'm taking junior level classes, which are some of the hardest. And it destroyed me honestly and I'm I'm literally still recovering because it was so hard"

Students also state they may feel unprepared to achieve their desired levels of success in some courses. They may anticipate that a class will be one way and, when they eventually attend, they find that the curriculum is different than expected or that there were other courses they could have taken that would have been more useful or interesting to them. Other students felt that their background knowledge did not prepare them enough to do their best. Some believed that the school itself had not prepared them, and others felt that they were underprepared due to uninformed choices they made in their class scheduling.

Example quotes from students highlighting *Student Difficulties* and feelings of unpreparedness
“I just-sometimes I just haven't found enough time to cover it all, and then, you know, tests come up-start coming up, and I just, you know, don't have enough knowledge to really do my best on those tests.”
“It was my fault that was, I had a choice between two different classes and the other one probably would have been more relevant”

Most of the students who participated in interviews praised their technical colleges for providing the skills needed to succeed in their courses at Clemson. They particularly valued the math courses at their technical colleges and, in many cases, felt they learned more in the smaller community college courses than they did in their larger lecture hall-style Clemson courses. However, for some students, the transition to Clemson caused difficulties. One such difficulty was that the students believed they had not taken math at a good time, or they felt that the adjustment from one teaching style to another put a strain on their learning.

Example quotes from students highlighting *Student Difficulties* in pre-Clemson preparedness
“But since I got an associate … I took my math course in the beginning of it. And then, two years later, I'm transferring to Clemson. So everything is kind of like I'm having to re-study everything.”
“When I went to the tech school it was um on a lot simpler. It's a lot more complex here. You have to- Really there's a lot of out of out of schoolwork that needs to be done as compared to what I'm used to”

Financial Aid

As a part of the SPECTRA program, the students are offered a need-based scholarship. As the scholarship is need-based, there are many ranges across which the students receive financial aid. Overall, the students expressed the aid they received from the SPECTRA program was a valuable aspect of the program. How they talked about their scholarships, generally fell into three categories.

The first group of students expressed that they would not have been able to attend Clemson without SPECTRA. For some in this group, they believed they may not have been able to attend any four-year university had they not received SPECTRA-provided aid.

Example quotes from students highlighting *Financial Aid* and their ability to attend Clemson
“SPECTRA is basically it's covering all my tuition, putting less strain on uh my family for having to pull out loans or anything like that. Um, it's been. It's actually really nice to be able to join this program, because I didn't know if I was gonna be able to go here without it. Like it's getting the email this summer was a blessing for sure”

“without SPECTRA I would take way too many loans, and even then… I actually had to go to try to, first of all, because I couldn't afford to go to a four years straight out of high school. So once I talked to [Instructor] after that [class number] class and learned about SPECTRA I was like-Finally, I have a chance that I can go to a four year and be able to afford it”
“having the SPECTRA scholarship… Honestly, I- I think without it, I don't know if i'd be able to afford to attend”

The second group of students expressed that, while Clemson was still an option for them, the aid provided by SPECTRA helped to lessen the burden they felt from college loans and allowed them to feel less threat of debt in the future. Often, the students expressed that this relief of monetary pressure helped them to feel less stressed and also may have helped them to afford items that would help them with their studies, such as electronics and fuel to get to campus.

Example quotes from students highlighting *Financial Aid* and financial related stress relief
“If I didn't get the scholarship, I still would have been able to attend, but I it kind of lowered my the private loan I had to get so I have, which is the one I have to pay back even before it's schools over. So that kind of reduces like stress a lot that's for sure.”
“You know affected me in a positive way. First the financial stuff really helped me like I didn't have to like stress a lot about you know my financial problems.”
“So one thing is, uh you will spend a lot of money on fuel. And SPECTRA that's where a lot of the money went, and then um my laptop, I had to get a laptop for school because I just use my desktop computer when I was going to community college”

The third group of students felt that receiving financial aid not only relieved financial stress but it also allowed them to focus better on their studies. For some, this meant no longer needing an additional job and being a full-time student.

Example quotes from students highlighting *Financial Aid* and focus on studies
“It made it just less stressful overall. I didn't have to worry so much about the money. It's more about focusing on grades, and that comes with its own struggles.”
“It made me a little you know more relaxed or you know concentrated because I'm not like thinking about you know loans and stuff so I'm like a little I'm like more just like focused on my studies”

University Benefits

Transitioning from their two-year college to Clemson has provided SPECTRA students with professional development. Students believe that their Clemson courses provide them with the skills and knowledge to succeed in their future jobs. They feel that the information they learn in

class is vital to what they will do in the workforce and provides them insight into the job possibilities that they have. Some students expressed that they believe they have more potential for their futures after learning about the possibilities of what they can do with their final degrees. Many believe that the classes they are taking provide them with knowledge and skills to do well in interviews, and many believe they could not get internships or co-ops without first taking certain courses.

Example quotes from students highlighting *University Benefits*
"this semester we're like doing a little bit we're kind of wrapping things up and getting ready to this for a senior year to be like a few classes that are like designed to get you ready for any industry."
"I've been enjoying here at Clemson. Like my hopes for my future job, like, what would I do in future, the expectations have just gone higher because I've-Clemson has helped me push my limits, and I would have settled for something which I know that I can do much better now"

Professional Benefits (SPECTRA Program)

Many of the students within the SPECTRA program feel that they are getting a positive experience and that the program is helping them to develop several professional skills. Among these are research experience, developing leadership skills, working with teams, developing presentation skills, and access to campus resources.

Participating in undergraduate research can benefit the transfer students' experience and the transition process. This seems to be reflected in interview data from SPECTRA students. They greatly enjoy the research and CI classes they take and are enthusiastic about sharing their projects and experience. One student credited their experience with SPECTRA research to wanting to pursue graduate school in the future.

Example quotes from students highlighting *SPECTRA Benefits* and undergraduate research
"it really has opened me up to the idea of graduate school. I came from a two-year technical college and I was like, go to Clemson and get my degree. Bachelor's, call it quits work, but I'm beginning to work and do this research has really got me thinking about maybe, I could do this. I could go to graduate school, seeing what it's like getting my masters. I don't know if I have really justified the time for a PhD yet, maybe later down the road."
"Um, honestly, being part of the creative inquiry was a big bonus, because I know a lot of my friends, you know, they didn't get that type of undergraduate research experience. Um, And you know, kind of open the doors to a couple more things, you know, working with uh [ACE Fellow] on her projects and stuff like that. So I mean being able to have the paper published through her, it was a neat experience, and not something I would have been able to accomplish without. You know, SPECTRA"

Through the projects, some students have taken on leadership roles. Not every student desired to be a leader; however, many were willing to step up if the opportunity arose.

Example quotes from students highlighting *SPECTRA Benefits* and leadership
"And there's a lot of leadership that I've been able to hold on to now and help other people find a direction with like some of their own personal projects. Um… And yeah, it's helped me tremendously."
"If it's a situation where we-we don't really know doing, and no one else the team is really-is really taking the leadership role, I'll step in."

Even if not taking a leadership position, many students valued the teamwork they experienced while working with fellow SPECTRA students. They enjoyed both the team research aspect and working together inside and outside of regular classes. Some students chose to work together on class projects and create groups to help each other with homework and group work.

Example quotes from students highlighting *SPECTRA Benefits* and teamwork
"I completely 100% endorse the cooperative aspects of the SPECTRA course. Just the continued partnership between semesters, the projects and activities we've done together outside of class, and the actual researching activities are very, very valuable. It is very valuable to me to have people that I can talk to, and that I know that I will continue to talk to for semesters to come, and continue having good cooperation with them as we continue on in the projects that we do."
"last semester I took statics and dynamics, one of the hardest courses for ME students, and there were several students in SPECTRA who are also in that course. So, it was very-it made it very easy to discuss with other students. Like, if I had an issue on a problem, there's always people I could talk to immediately just within SPECTRA."

Students also feel that the presentations they have done for SPECTRA have helped them feel more confident and build their presentation skills to a higher level.

Example quotes from students highlighting *SPECTRA Benefits* and presentation skills
"our research prompt selected to be in one of the research symposiums at the Watt Family Center, and that whole experience of working together to present our project with very other people-various other people and judges coming up to us, that was probably one of my favorite experiences in the SPECTRA program"
"They've definitely helped me with a lot of issues because the presentation, with the research, definitely helps my confidence a lot, and just being able to talk with people and cooperate with them in a long-for a long-term goal has definitely improved my morale a lot"

Interactions

Many students in their interviews emphasized the benefits that the SPECTRA cohort of students provides to one another. Within the cohort of students, they value the friendships they have formed, the acquaintanceships they have made, the familiarity that the other students provide, help in courses, and the chance to work with a diverse group.

Many students found that the closeness of their SPECTRA cohort has been a positive experience. They enjoy knowing and working with their peers, and some strongly value the friendships they have found in their cohort. For those who don't feel they have formed strong friendships, many students also appreciate that they have friendly acquaintances or familiar faces they can sit with in the dining hall or see around campus. They also value their connection to future engineers in a personal and professional relationship perspective.

Example quotes from students highlighting *Interactions* and social benefits
"I also have like, made a lot of friends also, like a lot of friends that go back and forth from [place of residence]. So we like, hang out after the class and then catch the bus to [place of residence] so it's really good. The teamwork is also good"
"But the SPECTRA program I've have been making a lot of really good connections with a lot of future engineers that I have had since my first semester here, and just made some really good connections that I don't think I would have had, were it not for the SPECTRA program"
"I think I get along with the majority of guys here in SPECTRA. It's always nice to see them on campus and say hi to them. I always … it's like, since I transferred here and it's a weird thing being like a junior but you don't really know anybody when it is really nice to have that feeling like this semester, that when I'm walking around campus for like 10 minutes there is a really good chance I'm going to run into somebody that I know well enough to say hi"

In addition to social benefits, the students found that many cohort members were excellent resources for help and support in their classes, mainly if there were many of them within one class. This was not found in all cases. Computer science majors, for which there were fewer participating students, mentioned that they did not experience these kinds of benefits. Students also liked that they could work with many types of engineers and form teams that they found to fill weaknesses and build strengths.

Example quotes from students highlighting *Interactions* and academic help
"You know I have other classes with some of the scholars, and it's definitely helpful to kind of have each other as just like. Oh, if I go now to do something on stuff with this. I can go ask them about it, or have them explain it to me."
"If I'm struggling, if I have a tough semester this semester, you can you can help me out and then next semester when thing when my workload isn't as great then i'll scratch your back you know."

“I think we have a mechanical engineer, and a computer engineer, as well as my civil engineering-so we have a lot of different backgrounds, that help a lot when it comes to covering weaknesses that we as a group have.”

Engineering Identity

SPECTRA students found that the program helped them to build their identity as engineers. Many believe they will not be considered “real” engineers until they obtain their degrees from Clemson. Others believe that they will be engineers when they get hands-on experience working; this can be working a job, or some consider their work from SPECTRA CIs as enough to call themselves an engineer. Several students related engineering identity to creating something physical or having an impact on society.

Example quotes from students highlighting *Engineering Identity*
“I think when I finally get some hands-on experience as to-as to what an engineer does, I think, then I’ll comfortably be able to call myself an engineer.”
“If our research paper for SPECTRA ends up having some significant findings and somebody actually uses it for um for like some research development as like a background or something then I guess I could consider myself an engineer at that point”
“I think the defining moment would be, like, actually doing a project with other people and actually, you know, making an impact, and this project, you know, impacting others in a good way. So, I think that will be the best defining moment.”

Discussion

Though SPECTRA is in early practice, several important themes are already shown in data derived from student interviews. The most compelling of these findings is how students interact with their cohort and the overall benefits they feel they are getting from participating in the program. These findings correlate strongly with research done by similar transfer programs.

Interacting and making connections with others is a vital part of the college experience and something that is particularly important for transfer students, who may have a more difficult time forming connections than students who began at a four-year university right after high school. It is important to make connections with people that you can relate to and form connections and bonds. Students have indicated that the SPECTRA program has allowed them to form bonds, connections, and friendships, some of which outlast the students' time in the program. The students believe that the personal connections and relationships formed with other students in SPECTRA have a high value to their experience at Clemson. Even in situations where the students did not feel that they formed a long-lasting friendship, they still appreciated the chance to meet and get to know one another casually. A few students highlighted their appreciation of being able to recognize more friendly faces on campus and have someone to say hello to as they make their way through campus, the dining hall, and campus-held events.

While not all bonds formed the foundation of friendships, there were several instances where the connections were more professional-based. The students who highlighted the professional aspects of their relationships with SPECTRA students valued the chance to work with several different types of majors, as they believed it gave them a chance to experience situations that may be similar to a future workplace. They also found that they were better able to connect professionally with SPECTRA students in their classes and used them as a resource in helping with homework, forming study groups, and having connections for classroom-related projects.

In addition to personal connections, the SPECTRA program has helped them to develop skills beyond what they learn in their classrooms and their coursework. The students believe that the courses they take at Clemson are vital to their ability to succeed in their future careers. They credit their classes with having provided them with knowledge, presentation skills, and critical thinking skills.

They perceive that SPECTRA has taken this base learning a step further by having the students participate in research. The research opportunities the students undergo allow them to develop a project with a Clemson graduate student and in some cases, the work done through SPECTRA has resulted in paper publications. Through participating in undergraduate research, the students have been encouraged to take on greater leadership positions or figure out amongst themselves how each of them would like to fall into place within a group research setting (much like they might be doing in their future working in industry). The SPECTRA research opportunity has also allowed them to work with other students who may be from departments outside of their majors. This, again, is highlighted as a chance to experience what their potential careers and working on projects may be like in the future when they may be working with a diverse team.

Perhaps one of the most impactful aspects of the SPECTRA program for students is the provision of financial aid. While some students believed that the financial relief was a way to better focus on classes and achieve higher grades and success, some students indicated that without the SPECTRA scholarship, they would have been unlikely to have been able to attend Clemson, or perhaps they may have been unable to pursue an engineering degree at all.

Conclusion

The SPECTRA program is designed to aid low-income technical college students transferring to Clemson University and increase student recruitment, retention, academic success, and graduation rates for technical college transfer students. The formative findings from this project highlight the challenges transfer students face in their transition to a new university and the positive impact of the SPECTRA program at Clemson University. The data indicates that the program provides significant benefits to students, including financial aid, professional development opportunities, and the formation of personal and professional connections. Through these benefits, students can develop critical thinking skills, enhance their job preparedness, and focus on their studies. These findings are consistent with research on similar transfer programs and demonstrate the importance of programs like SPECTRA in supporting students in their academic and career goals. Overall, the SPECTRA program has the potential to be a valuable resource for transfer students and their success at Clemson University.

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