Investigating Women's Learning Experiences in Computing through the Lens of Schlossberg's Transition Theory

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***Abstract*—This paper reviews the application of Schlossberg's transition theory in understanding the learning experiences of women in computing. Computing education communities have been consistently exploring approaches and strategies to increase the participation of underrepresented groups. Even though efforts are being made, it remains challenging to address the shortage of highly skilled computing professionals, and gender disparities still persist. A primary goal in computing education is to attract and engage with this historically minoritized population to retain them in the field for long-term contributions. In this pursuit, we propose reviewing Schlossberg's transition theory in the context of women in computing education to understand how to improve their learning experiences and improve their long-term engagement.**

Transition theory examines how individuals identify with and adapt to a changing situation in their personal and professional lives. In this study, we focus on non-computing women, those who have earned bachelor's degrees in non-computing fields but wish to change their career directions to computing after completing their undergraduate education. We argue that non-computing women have deferred interests in computing, so they leverage these learning experiences to facilitate their computing career transition. It is important to investigate non-computing women's learning experiences to gain a comprehensive understanding of how they navigate the transition process. Schlossberg's transition theory, originally developed for adult education and career counseling, provides a framework to guide our inquiry into women's interpretations of computing career transitions and for determining which resources are best suited to support them during the process. This paper seeks to synthesize relevant literature on Schlossberg's transition theory in engineering and computing education, focusing on the underrepresentation of women in computing. It explores broadening the application of Schlossberg's transition theory by applying it to the study of non-computing women to inquire into how it can help disrupt gender disparities in computing education. Our discussion of Schlossberg's transition theory also demonstrates how this theory is appropriate to study the non-computing women's career transition in computing and outlines future studies that can further the discoveries in engineering and computing education research.

***Index Terms*—Women in Computing, Broadening Participation, Computing Careers, Computing Education**

I. Introduction

As the technology industry continues to expand and accelerate, there is an ever-growing demand for highly skilled computing professionals. In the United States, it is anticipated that job opportunities in the field of computer and information technology will increase by a significant 15% within the next ten years [1]. This projection highlights the importance of computing professionals' role in our rapidly evolving digital world. In the meantime, the computing industry continues to face a significant challenge in finding skilled workers, particularly among historically marginalized groups like women. There is concern that women make up 70% of the workforce in jobs at high risk of automation, potentially leading to job loss [2] that can further inequity in the workforce. This situation emphasizes the need for proactive approaches to ensure that women and other marginalized groups have access to learning and training opportunities that will enable them to thrive in the changing job market. Despite the ongoing efforts by the computing education community to broaden participation, there are still gender disparities that persist [3]. This poses a challenge in achieving a computing workforce that is more inclusive and representative. The field of engineering and computing education is striving to encourage more women to participate. To ensure their continued engagement and valuable contributions, it is crucial to identify effective strategies for attracting and retaining women in computing. To maximize the participation of women in computing, we propose reviewing Schlossberg's transition theory in the context of women in computing education to understand how to optimize their learning experiences to improve their long-term engagement.

Schlossberg's transition theory is a theoretical framework that explores the various strategies and techniques individuals can employ to cope with the challenges and uncertainties associated with transitions in their personal and professional lives [4], [5]. Our study focuses on *non-computing women*, defined as post-baccalaureate women who have obtained a bachelor's degree in a field other than computing but desire to shift their career paths toward computing after completing

their undergraduate education. We argue that non-computing women have deferred interests in computing, so they leverage these learning experiences to facilitate their computing career transition. In order to better facilitate our inquiry, we have provided a specific definition of "*computing career transitions*." This term refers to the learning experiences of women switching from non-computing backgrounds to job positions or related fields in computing. Schlossberg's transition theory provides a framework to guide our inquiry into women's interpretations of computing career transitions and determine which resources they leverage to support them during the process. This framework was initially developed for adult education and career counseling, making it suitable to apply to our study context. Investigating non-computing women's learning experiences is essential to understand how they navigate the transition process.

The purpose of this paper is twofold: firstly, to present a synthesis of the relevant literature on the utilization of Schlossberg's transition theory in engineering and computing education, aiming to address the underrepresentation of women in computing; secondly, to explore the application of Schlossberg's transition theory in broadening its scope to encompass non-computing women and computing career transitions. This discussion will also include implications for prospective research to expand the body of literature associated with underrepresented groups, particularly non-computing women. The rest of the paper is structured as follows: We first provide background information on non-computing women in engineering and computing and the rationale for examining their computing career transitions. Then, we synthesize relevant literature focusing on Schlossberg's transition theory in engineering and computing education research. Next, we delve deeper into how we can apply Schlossberg's transition theory to study non-computing women's computing career transitions. Finally, we suggest future research implications to expand this framework for conducting computing education research on women in computing.

II. Overview of Schlossberg's transition theory

Schlossberg's transition theory was explicitly designed to support counselors who assist adults undergoing significant life changes. It explains that a transition is a change in behavior and perception that occurs due to a significant event or the absence of such an event. Experiencing a transition period can be a challenging journey, with positive and negative aspects that can impact one's ability to adapt to new circumstances. The model consists of three phases: *moving in*, *moving through*, and *moving out*. In order to successfully navigate through each phase, it is crucial to be prepared to adapt and assume any necessary roles. It is imperative to recognize that every phase presents its own set of challenges and requires a unique approach to ensure success. During the *moving in* phase, a person becomes more familiar with a new system as they may develop new roles, relationships, routines, and beliefs. During the *moving through* phase, individuals experience a period of neutrality as they seek to find a balance between the old and the new while also engaging in a cycle of renewal. The *moving out* phase refers to the process of separating oneself from a particular role or situation. This can lead to feelings of grief and detachment from past relationships, routines, and assumptions. It is important to note that Schlossberg believed transition is a continuous process without a definite end point [6].

After introducing the model, Schlossberg and colleagues [4]–[7] expanded the model in later years by outlining three essential parts: approaching transition, taking stock of coping resources, and taking charge. The first part of this model investigated the factors affecting adults who undergo a transition, including anticipated events such as graduation, marriage, or retirement, as well as unexpected events like job loss, illness, or death. The author also proposed that a non-event, an event that was expected but did not occur, can create a time of transition. Experiencing a feeling of instability, known as disequilibrium, is a normal aspect of any transition. Every transition is expected to come with unique challenges and opportunities for personal development and advancement [6]. The phase of taking stock of coping resources involves examining the individual's current resources and identifying additional support they may need to navigate the transition. The ease of adapting to a transition depends on an individual's balance of resources and deficits related to the transition, the environment, and their sense of competence and well-being. The taking charge phase involves individuals accessing or activating strategies to navigate the transition. Essentially, it involves identifying a transition, navigating it, and ultimately moving forward.

In the second part of the model, Schlossberg [4], [5] identified the 4S System as four key factors that positively affect adult transitions. The 4S System is as follows:

- *Situation*: the person's situation at the time of transition
- *Self*: the person's inner strength for coping
- *Supports*: the support available during the transition
- *Strategies*: coping strategies used to handle the transition

Each individual approaches transitions uniquely. Understanding an individual's attributes, including their personality, values, beliefs, and attitudes, is essential to help them navigate the transition effectively. Each factor of the 4S system can serve as a resource or deficit, depending on the person's physical, social, and mental state and the resources available to them. It is critical to determine if the 4S system is sufficient to support the change during the transition and, if not, explore approaches to strengthen them.

As discussed above, Schlossberg's transition theory provides effective techniques for helping individuals understand and navigate transitions. It has been used to study transitions in diverse contexts such as marriage, divorce, the military, education, careers, and retirement [6]. With the development of its models, it has been starting to gain attention in recent years in education research as starting university or changing careers can become major life changes.

III. Methods

In this section, we will discuss the methods used to collect the related literature. First, we searched for "Schlossberg's transition theory" to identify the foundational papers that established this theory to allow us to conduct an overview of this theoretical framework. Then, we searched for literature relevant to the scope of non-computing women's career transitions to computing. We used the following terms: "Schlossberg's transition theory," "women," AND "computing." The results were very limited, requiring broader search terms to "Schlossberg's transition theory" AND "engineering" or "computing" AND "women." Computing as a domain can also be referred to as computer science, computing workforce, and CS. We included these variations to identify the literature related to the scope of this review.

Given that this paper focuses on applying Schlossberg's theory to education research, we broadened the search term to include "education" combined with the previous search queries to obtain a literature base. After several iterations of search queries, we noticed the repeated search results in the literature, and we shifted to snowballing the collected literature. Except for the foundational theory papers, we bound the literature by publication year after 2010 for this study. The following sections will explore the research by synthesizing Schlossberg's theory in education research, then discuss how it would be appropriate for studying non-computing women's computing career transitions.

IV. Schlossberg's transition theory in Education Research

In education research, Schlossberg's transition theory is used to help students and educators understand the challenges students face when transitioning from one phase of their academic journey to another. With a focus on adult development [4], [5], this theory is often used in studying higher education and can include various types of transitions, such as moving from primary to secondary school, graduating from high school, starting university, transitioning during/at college, or transitioning to work. It can also be further categorized by the population who has been undergoing transition experiences, such as first-year college students, student athletes, adult learners, veterans, etc. Schlossberg's transition theory has been commonly used to identify coping resources that aid in facilitating educational transitions across various demographics and types of transitions.

A. Schlossberg's Transition Theory in Higher Education

Initially designed for adult education, Schlossberg's transition theory has been adapted to examine and support transitions for diverse populations in higher education institutions. What makes Schlossberg's framework stand out from other theories of the transition phenomenon is its asset-based framing [4], [8]. This approach enables individuals to balance their assets and liabilities while choosing coping resources during the transition phases, resulting in positive transitions [8].

Although a prior study has recommended utilizing Schlossberg's framework for all students [9], it has been widely applied to the population of athletes and veterans transitioning into higher education programs. One of the key assets for individuals to cope with educational transitions is their support systems [4], [10]. In a study conducted by Flowers, Luzynski, and Zamani-Gallaher [11], Schlossberg's model was utilized to investigate the perspectives of transfer student-athletes. The findings revealed that transfer student-athletes possessed a degree of self-reliance when transferring. However, they also relied on the athletic support systems offered by most universities. This study further indicated that student-athletes frequently opted to transfer due to athletic motivations. They often depended on a narrow support network of family members and individuals in the athletic department.

Another dominant population that has been widely using Schlossberg's model is military veterans. Through the use of this framework, multiple studies have found that the key asset for veterans to persist and succeed during transitions is when higher education institutions acknowledge their unique needs and offer them necessary resources and support [12]–[15]. Nevertheless, the resources and support these institutions provide may not always be adequate [15], or veterans may choose not to participate in the supporting programs available on campus [16]. Another study reported that veterans often encountered difficulties transitioning from a structured and highly-disciplined living and working environment to a more open and flexible setting in higher education institutions. This can pose a significant challenge as they must learn to navigate a new system of self-direction and independence, which may require different skills and strategies to succeed [17].

Besides identifying assets supporting individuals' transitions, Schlossberg's framework has efficiently identified the challenges adult learners face when seeking undergraduate education. A narrative study [18] found that adult learners face barriers to college enrollment, such as difficulties with technology and health-related issues. Addressing the challenges that adult learners face in transition programs is crucial for better supporting them, and understanding their experiences and perspectives can help them achieve their educational goals. Another study [19] found that new or returning adult students experience difficulties around work-life balance and financial limitations when shifting to higher education. Colleges and universities must be mindful of the student population they serve and be intentional in providing support for that population to ensure smooth transitions.

Lastly, Schlossberg's transition theory has been applied in previous higher education research studies to obtain a more comprehensive understanding of college students' transition experiences internationally. A study [20] was conducted in Africa to assess the factors influencing the transition process. This study serves as one example of an application of this model at the college level; the study examined factors that impacted students' transitions, including family support, academic preparedness, and resource availability. Another study [21] conducted in Asia used Schlossberg's model to guide

the phenomenological approach to conducting interviews. The data was collected from 19 international undergraduate students enrolled in a local private university. According to this study, students' experiences were shaped by their aspirations, emotions, and expectations. These experiences included mixed emotions when leaving their home country, memorable moments of exploration, and difficulties related to weather, food, academics, and homesickness. Finally, a European [22] study utilized Schlossberg's model to create survey questions that focused on identifying the resources available to college students in their final years to facilitate a smoother transition into the workforce. These studies have provided valuable insights into the transition experiences of college-level students from an international context. It further demonstrated that Schlossberg's transition theory could be flexible in adapting to a different cultural and demographic setting of education research.

B. Schlossberg's Transition Theory in Engineering and Computing Education

While Schlossberg's transition theory has been used to understand students undergoing transitions, limited studies have been conducted within engineering and computing education research. The 4S system outlined by this model provides a structured approach for a more holistic exploration of transition experiences from underrepresented groups in the discipline [12], [23]–[26]. Studies in engineering and computing education have commonly used a qualitative research design, emphasizing the significance of adequate support from faculty, staff, and family despite differences in study settings. Specifically, Boyd-Sinkler's work [23] demonstrated how the 4S system could help to conduct multi-case qualitative studies to explore African and Hispanic/Latinx students first-year engineering students. Another study used qualitative interviews to reveal that underrepresented students enjoyed their prior exposure to science, technology, engineering, and math (STEM) activities and courses [24]. With support from family and the financial stability of engineering, they choose engineering as their academic major. However, they often face challenges during their transitions to college, including application materials, demanding coursework, financial concerns, and feeling overwhelmed. Next, Naughton [25] used a phenomenological approach focusing on women's experiences as first-year engineering students and highlighted the contributions of support in women's retention in engineering. It also highlighted the importance of normalizing the experiences of failing as part of the learning process and encouraging students to develop self-talk that helps them learn from failure. Besides the importance of support, Main's work [12] utilized comparative case studies with an explanatory inquiry approach to explore the how and why of the transition experiences in engineering. The work revealed differences between underrepresented and traditional students when it comes to balancing academic and family lives, underscoring the importance of studying the unique transition experiences faced by underrepresented students.

There have been even fewer studies on the use of Schlossberg's transition theory in computing education compared to engineering education. However, the existing studies have primarily focused on underrepresented minorities, and how researchers have applied this theory could serve as inspiration for future research in computing education using Schlossberg's model. Hargrave, Jacques, and Cobham [17] explored veterans' transition experiences into the postgraduate computer science program designed for serving military personnel. One of the key findings from this study indicated that military students frequently require additional support or extension of their studies in order to complete the computer sciences program successfully. The researchers were able to design the survey and a follow-up interview to analyze the unique challenges faced by students based on the 4S system. This mixed-methods approach allowed the researchers to identify why students need additional time to learn computer science. It also outlined the effective supporting mechanisms that can assist this unique group of students in achieving their academic goals. Battern et al. [26] utilized this framework to study the strategies students leveraged as transfer students in computer science programs from a 2-year college to a 4-year university. In addition to the typical approach to adopting the 4S system for constructing instruments or protocols used in the move-through phases of the transition experiences, this study utilized Schlossberg's framework to identify critical transition points through the overall transition experiences. In this way, the authors were able to conduct a cross-sectional inquiry design to identify the appealingness of such a transfer program for first-generation college students in computing, primarily for Black and Hispanic students. The findings further implied that it would be beneficial for both institutions to implement policies and procedures that support transfer students throughout their transition process to encourage and promote diversity within the field of computing.

C. Schlossberg's Transition Theory on Women

The literature reviewed suggests that combining Schlossberg's framework with a phenomenological approach often enables an in-depth inquiry into the lived experiences of underrepresented groups experiencing transitions, such as women. For instance, Naughton's work [25] explored the experiences of women engineering majors who transitioned to community colleges and persisted to the second year. With a reflective-interpretive approach to hermeneutic phenomenology, data were collected through protocol writing, interviews, and focus groups and analyzed thematically. The study described women's transition experiences in engineering consisting of differences between high school and college, group projects, hands-on learning, complex course content, and learning from failure. It further described social experiences illustrating the prevalence of underrepresentation of women, sexism, and microaggressions in engineering. Some additional studies focused on women that adopted a phenomenological approach are worth noting. Salahuddin [27] adopted the phenomenological approach to study women entrepreneurs' career tran-

sitions in an international setting. Cherrstrom and Alfred [28] explored the unique challenges and career strategies of women midlife career changers to the professoriate. Gbogbo [29] conducted an interpretative phenomenological analysis to study the transitions of the adolescent through pregnancy and motherhood. Pellegrino [30] explored women veterans' transition experiences and identified the issues that further complicated transitions, such as motherhood and marriage. Those phenomenological studies focusing on women's transition experiences were able to account for the multiple life stages, life roles, and intersection of identities of women's transition experiences when integrating Schlossberg's framework into the analysis.

D. Identifying Areas for Future Education Research

Transitions are complex and multifaceted experiences, and exploring such phenomena through the lens of Schlossberg's transition theory has gained increased attention in recent years. Although there has been extensive research on applying this framework to education research, further studies are needed to expand its application to computing and engineering education. Several studies have focused on college students' transition experiences, but there has been limited research on post-baccalaureate populations' transitions. This presents a great opportunity to gain insights into the factors that influence transitions and the challenges individuals encounter when they desire to transition later in life. Qualitative research has advantages in capturing the detailed lived experiences of individuals undergoing transitions. It offers rich insights that facilitate these transitions based on the 4S system outlined by the theory. However, capturing the extensive details of individual transitions is very time-consuming, which is why we often see dissertation work using this framework. Another potential direction to expand future research is to supplement qualitative research with other types of methodologies to balance the level of detail needed from the transition experiences, meanwhile reducing the time required to complete this work. When discussing education or career transitions, most studies have focused on those of athletes and veterans. This work has laid the foundation for expansion to a broader range of discipline contexts to examine career transitions in these fields. One topic that requires further exploration in the future is career transition experiences in the fields of engineering and computing. As the pace of technology continues to accelerate, individuals can find it increasingly difficult to transition into high-growth fields or to maintain their competitiveness in computing and engineering. As a result, It is essential to attract individuals to transition into computing careers and to assist them in updating their skillset to improve the diversity of the computing workforce. Understanding the factors that lead to successful career transitions in the computing industry is essential for fostering a workforce that can adapt to the constantly evolving landscape.

V. Applying Schlossberg's transition theory to Non-computing Women

Attracting and retaining more women in computing is not just a matter of fairness and equity – it is also a crucial component of ensuring that the industry remains innovative in the years to come. Prior studies have demonstrated that diverse teams increase creativity, productivity, and innovation [31], [32]. Consequently, it is essential to acknowledge that a more inclusive computing community will ultimately be advantageous for all. However, stereotypes, biases, college curriculum, and workplace environment are factors underlying the underrepresentation of women in engineering and computing [31], [32]. Although the engineering and computing research communities have been working on broadening participation, most research has concentrated on K-12 and college students [33], [34]. While studying educational pathways is critical, taking immediate action and investigating other potential solutions that may have been overlooked in the current research landscape are equally important. There is a need for more exploration in the post-baccalaureate population, particularly among women [35], [36]. Women tend to defer their interest in computing due to the absence of early exposure to it [37], affecting their career aspirations in computing [38]. Unfortunately, when they want to explore computing later in life, they often receive an unfair perception of their ability to learn computing [39]–[41]. This is a huge missed opportunity to engage with women who developed a passion for computing later in life.

To demonstrate the application of Schlossberg's transition theory to study non-computing women's career transition experiences, we adapted the original model, as shown in Figure 1. To recall, we defined the learning experience for non-computing women to switch from a non-computing background to a job position in computing or related fields as computing career transitions. We were able to further conceptualize the computing career transitions into three phases:

- a *moving in* phase for women who have non-computing backgrounds
- a *moving through* phase to allow non-computing women to utilize the coping resources
- a *moving out* phase to a positive computing career transition with a job in computing or related fields.

Focusing on envisioning the 4S system as the coping resource can assist in identifying the relevant assets to emphasize the importance of non-computing women's perception of computing career transitions. The authors explored the adapted model in a content analysis by formulating a structured tabulated list with computing career transitions based on the 4S system [36]. This approach is effective in identifying coping resources for self, situation, and strategies associated with non-computing women's LinkedIn profiles. At the same time, it underscored the missing support resources through the publicly available profiles, indicating the need for future follow-up studies.

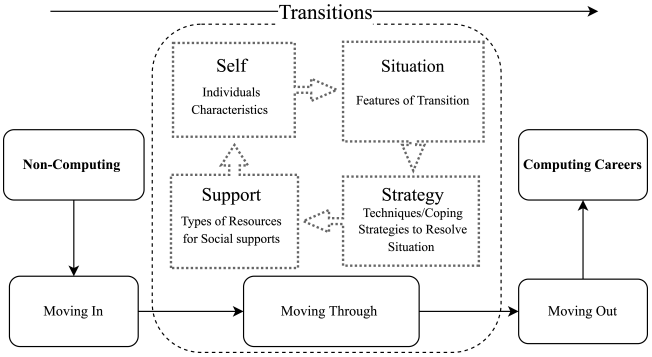

Fig. 1. Transition Model, Adapted from Schlossberg

Schlossberg's transition theory is a valuable framework to aid in improving our understanding of how to better support non-computing women's transitions into computing careers. Applying it within under-studied fields of engineering and computing education offers several advantages that are worth noting. First, this framework is able to structure the transitions not only based on the phases of the transitions (moving in, moving through, and moving out) but also by leveraging the 4S system to outline the coping resources utilized by non-computing women's transitions. It is a versatile framework allowing researchers to dive deep into the unique transition experiences through any phase of non-computing women's computing career transitions. Second, it is appropriate and effective for studying underrepresented populations in engineering and computing fields, especially when the targeted populations are coupled with the intersection of multiple life stages, life roles, and identities of women in computing. As an asset-based model, Schlossberg's transition theory supports the efforts of promoting anti-deficit approaches in our community by highlighting the strengths and resources non-computing women possess as assets to overcome challenges through the transition experiences. Finally, this theory captures aspects of transitions that are not often defined in other theories. For example, this theory provides the perspective of viewing transitions as "a continuous process without a definite end point" [4], [6]. This aspect is relevant to computing, where life-long learning to keep up with the most recent technologies is a central theme.

VI. Implications of Future Research

Building upon previous research conducted within engineering and computing education, researchers can gain a deeper understanding of the computing learning experiences of underrepresented minorities, especially women, by applying Schlossberg's theory. Utilizing an established framework to explore an under-explored population in computing can significantly impact the practices of broadening participation to enhance diversity and inclusivity in the computing industry. Moreover, Schlossberg's model emphasizes the importance of a holistic approach that is effective in analyzing students' transitions by evaluating adaptive and maladaptive coping mechanisms students use [4], [5], [8]. In response to the community's efforts calling for more research using asset-based approaches in engineering and computing education, applying this framework can focus on identifying individuals' strengths and resources that can serve as the assets to navigate any transitions. As most research using Schlossberg's model has relied on qualitative methods, there is value added in expanding to research methodologies for future studies. Mixed-methods research is a methodology that can bridge the gap between qualitative and quantitative approaches, allowing each approach to supplement the other. We encourage engineering and computing education researchers to consider adopting mixed-methods approaches using Schlossberg's framework for future studies.

Another important aspect of this framework is that it can further expand its consideration of social justice issues to provide a more integrated and holistic approach [6] to understand further issues associated with diversity, equity, and inclusivity in our field. With the rising concerns of fairness of technology, we will be able to integrate ethical and justice considerations in identifying the assets to navigate positive transition experiences to computing when conducting engineering and computing education research. Understanding the transition experiences of non-computing women through this asset-based holistic approach not only aids our understanding of how this under-studied population thrives in the computing career transitions but also strives to promote the overall diversity, equity, and inclusivity of the computing workforce.

VII. Conclusion

This paper reviews the application of Schlossberg's transition theory in education research focusing on engineering and computing education. Prior literature has demonstrated that this framework can be effective in studying complex and multifaceted transitions in various populations and contexts in education research. There is potential to expand its application to post-baccalaureate populations with different types of transitions in computing and engineering education, particularly among women. This paper further discusses how it can be applied to facilitate the understanding of the learning experiences of non-computing women who desire to transition to computing careers later in their career trajectories. In order to identify the resources non-computing women require for positive transition experiences into the field of computing, we encourage the use of this established theoretical framework to guide future inquiry. Schlossberg's model is a practical framework for pinpointing appropriate resources to facilitate transitions and gain practical insights that can significantly improve the retention and engagement of women in the computing industry. This study further highlights the importance of exploring the learning experiences of women who missed early exposure to computing. Exploring additional research in the current research agenda in engineering and computing education is critical to attracting and engaging historically minoritized populations in this discipline and retaining them for long-term contributions. Additionally, the paper demon-

strates how this theory is appropriate and adequate to study the non-computing women's career transition in computing and outlines future studies that can further research discoveries in engineering and computing education research.

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