

Where are the women? Perceived Barriers to Engineering Education: A review of feminist influences on curriculum in British Columbia that contribute to the persisting and evolving barriers to women's entry into engineering education

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Abstract

The population of engineers is insufficient to meet long-term demand; although immigration is boosting the numbers and adding diversity to the mix, women are still severely under-represented^{1,2}. The recruitment of women into these programs is a clear opportunity to meet industry demand for engineers. Young women occupy an increasing percentage of the seats in high school physics classrooms^{3,4}. This paper explores why these women pursue unrelated careers – instead of applied physical sciences – by reviewing, decade-by-decade, the history of feminist influences on education in British Columbia and on Canadian society.

Keywords

Engineering Education; Gender; Stereotypes; Feminist Influences; STEM

Introduction

Young women occupy an increasing percentage of the seats in high school physics classrooms yet they do not, for the most part, enter post-secondary programs in engineering or physics^{4,3}. This paper explores the possible ongoing societal reasons for this phenomenon by reviewing, decade-by-decade, the history of feminist influences on education in British Columbia and on Canadian society.

Feminist activism has had pervasive influences on society, far beyond the acquisition of a desired right or privilege⁵⁻⁸. This essay describes how the three waves of feminism have influenced public school and post-secondary curriculum in British Columbia, and how those changes may correspond to the continuing gender gap in post-secondary education for STEM areas: science, technology, engineering and mathematics.

The three waves of feminism were very different with respect to activism and urgency. The first wave consisted of increasing participation of women in political and social life and rising levels of education. Women acquired the right to vote and started working outside of the home in teaching and clerical occupations. The second wave is noted for the militant activism of the women's liberation movement and, in Canada, the 167 recommendations of the Royal Commission on the Status of Women, resulting in legislated equality for women in work, education and law. The activism of the second wave of feminism produced the majority of curriculum feminization and raised concerns about the effect of feminized curriculum on boys.

The third wave, also called post-feminism, is a time of confusion for most girls and women who believe they live in a society of equality but experience sexism in many obvious and hidden ways. Curriculum documents no longer mention feminist requirements but focus on aboriginal and racial diversity, reflecting the post-feminist culture that women are equal and sexism no longer needs mentioning. The post-feminist constructs of Girl Power and Successful Girls send the message that girls can do and have anything, yet barriers to engineering and other careers in the physical sciences continue to deter women from entering those careers.

History textbooks are good indicators of how well social knowledge is transmitted to younger generations and, according to Jane Gaskell^{9,10}, textbooks from the first wave rarely included references to women's experiences. The early feminists attempted to initiate changes to the curriculum in their role as teachers, setting lesson plans and writing texts to introduce students to issues relevant to life in the home and building a foundation for – or maybe driving – the second wave of feminism¹¹⁻¹⁶. Coinciding with racial activism, the second wave was replete with militant affirmative action¹⁷, which alienated some from the growing women's liberation movements across Canada, the United States and Britain¹⁸⁻²⁰. History textbooks in use during this time reflect the extreme positions: most authors held on to androcentric depictions of major events, yet some included multiple references to women's contribution to historical events¹². The third wave of feminism, also referred to as post-feminism, is marked by a mood of inclusivity, welcoming full diversity and fighting not for women's rights but rather for equality and fairness for all sub groups²¹. Expanding on the observations of Pomerantz and Raby, if one could ask a female engineer or physicist today, she would likely say she self-identifies without a gender tag because she will have grown up in a society that values diversity and multiple standpoints, and where all things are possible for all people. Yet she will also likely say she has experienced direct sexism at some point in her life – through disparaging actions or comments at work or discouragement at home – and felt powerless to overcome it²².

The first wave of feminism

The first wave of feminism began in the late 1870s and lasted through to 1940 with the passing of the women's suffrage bill in Quebec¹⁷. This period is marked by a rapid growth of women's organizations, and an increasing female desire to be socially and politically active.

Women attained the right to vote as early as 1916 in some provinces, moving women's political action from the sitting room to the public realm¹⁷. Yet, Clark¹² notes that at the turn of the 20th century many Canadian women were not simply housewives but true homemakers, responsible for producing all of the needs within the home. As settlers, women took care of the domestic duties¹² and were socially and politically active in the schools, churches, and organizations like the Women's Christian Temperance Union, the International Order of the Daughters of the Empire, and the National Council of Women of Canada²³. These organizations, according to Doris Anderson, focused on improving the broader society by caring for the ill, raising funds for shelters and orphanages, and interacting in the political sphere; these influential women were highly engaged in their social work, and coordinated their efforts to claim civic rights for women. The first wave of feminism was a period of women's increasingly active participation in the politics of society¹⁰.

Women's duties in and out of the home complemented the contribution of working-class men who were farmers or labourers. Education was readily available and, by the 1890s, many Canadian universities began to accept women as students, although quotas were typically set to limit the number of female students accepted⁶. During this time, levels of education rose for men and women, resulting in rising demand for skilled workers⁵. Between 1910 and 1940, the number of clerical jobs rose quickly and, when the men left to fight in World War I, working women filled most of these positions. Women typically returned to the home after marriage to care for the family and often engaged in unpaid socially oriented volunteer work.

As time passed, women's education levels continued to rise. Women were reported to be excellent teachers and in greater demand than male teachers who were said to have lacked "one or all of the three G's: Go, Grit and Gumption", according to the 1908 Alberta Department of Education, as quoted in Coulter & Greig¹¹, but this preference for hiring women as teachers was more likely financially driven. Male teachers tried to attain sanctioned pay discrimination in teaching, so they could be recognized as distinct from female teachers and achieve professional wages and status, restricted to men at this time in history. Unfortunately for them, society was not prepared to recognize male teachers for choosing to work in what was fast becoming a women's career²⁴. Still, men were paid more than women – \$487 per month compared to the average woman's salary of \$130 per month – and women appeared to willingly be "seen as rendering a service out of love and...[therefore] not expect high levels of remuneration or autonomy"¹¹.

During the second industrial revolution, men moved into manufacturing jobs, leaving more of the clerical positions to educated women⁵. Women were encouraged to pursue these clerical positions as they were deemed suitable feminine roles. In fact, clinical experts of the 1940s and 1950s studied and identified women's best qualities as "passivity, nurturance and concern for others [while downplaying] intellectual achievement and mastery needs"¹⁰. Women were encouraged to cultivate these traits as assets for clerical work.

Interestingly, textbooks of the time rarely mentioned women's contributions to society. Penny Clark¹² reviewed the history textbooks that were either required or recommended by the BC Ministry of Education, tracking references to women's experiences in order to measure the influence of feminism on curriculum. The books in use in the early 20th century only mentioned a woman if she was a queen commanding an expedition or a heroine like Laura Secord or, perhaps, one of the *filles du roi*, sent to New France to be "a nice little wife to make things pleasant"¹². Otherwise, women were not mentioned at all. Androcentric depictions of history created the sense that women are peripheral to history or deliberately overlooked. This is not the case, according to Clark, but rather in indication that the questions used to guide authors in creating the textbooks did not relate to women's contributions.

Post World War II

From the time that women won the right to vote, they began participating in government as elected members. Women's education rates greatly increased but discrimination was rampant: universities set quotas to limit the number of women permitted to register, managers used sexist hiring practices and laws were biased towards men²³. The Canadian government established the Royal Commission on the Status of Women in Canada in 1967 to examine women's place in

Canadian society. In 1970, the Royal Commission presented 167 recommendations to recognize and foster the rights of women in employment, education and law¹⁷. Women's groups, coalitions, and liberation movements thrived in their work for the equality of women. Women entered the paid workforce in earnest, representing 32.7% of workers by 1970¹². Surveys conducted at the time indicated that women also performed most or all the work in the home.

Support for the feminist movement paralleled Canadians' rising tolerance towards races and creeds, which some authors suggest was in reaction to "Hitler's racism, the decline of close ties to Britain, and the impact of the American Civil Rights Movement", in the words of J. Donald Wilson¹². Canadian nationalistic pride increased dramatically in support of events like the successful world exposition in Montreal and the election of the charismatic Pierre Elliot Trudeau as Prime Minister, and BC history books were quickly rewritten to add Canadian quotes and references²⁵.

Until the Royal Commission published its recommendations, however, the feminist influence on curriculum was low^{10,12}. In the 1950s and 1960s, few textbooks included discussions about the contributions of women to history, but still, only if they were royalty or writers of note. As the women's liberation movement and other coalitions gathered momentum, however, curriculum changes were more dramatic. Popular resistance arose against the feminization of curriculum because of beliefs that a "feminized school environment that denied boys' natural way of being was turning boys into sissies"¹¹. Sociologists, male and female, advocated for more male teachers in the classroom, to make schools more hospitable to boys, but only of the "right kind": a "virile, rugged, manly man, one who could re-masculinize boys by providing a hegemonic model of masculinity". After all, according to reports of the time, the "wrong" kind "may be worse than women"¹¹.

Still, through the 1970s, the Canadian women's movement made concerted efforts to change the public school system in British Columbia. Jane Gaskell wrote that "equality between the sexes became a legitimate policy issue, debated in schools, school boards, ministries and teachers' federations"²⁶. Rewritten and new textbooks were screened for appropriate portrayals of women, and "women's history and novels by feminists, even the occasional women's studies course, were added to the curriculum".

Some academic writers of the time expressed concerns that women's issues were supplanting legitimate historical content^{13,25}. However, the Royal Commission was clear in its recommendations that were formulated after reviewing elementary reading, social studies, mathematics and guidance texts, concluding: "This analysis of sex role imagery ... clearly indicates that a woman's creative and intellectual potential is either underplayed or ignored in the education of children from their earliest years"¹⁷.

Naomi Weisstein's 1969 lecture enabled the societal realization that gender roles – definitions of what women need and want – are psychological and social constructs:

With this realization, feminist educators began to take an activist stance toward curricular and pedagogical reform. During the 1970s and early 1980s they struggled to integrate the study of women and minorities into existing courses, initiated women's studies programs, and mainstreamed women's studies course.¹⁴

There was no consensus, in the 1960s and 1970s, about what a woman's role should be, but the Royal Commission provided official sanction for women to make their own decisions about their future. Some looked for work outside the home, others saw their role as a woman was to work inside the home, but in either case their work was valued lower than men's work¹⁰. This confusion was passed on to girls:

In sum, girls are told to be obedient and do what the school requires. But if they really succeed at this, they are contradicting another feminine imperative, which is to allow males to win.¹⁰

The conflict was more apparent when women adopted both male and female roles: Pomerantz and Raby²¹ give the example of an individual who, as scientist, must meet role expectations normally aligning with traditionally male expectations while at the same time, as woman, must meet role expectations normally aligning with traditionally female expectations. This is the "superwoman" construct of the second wave of feminism, that women can "both [work] and [raise] a family without compromise on either front"²¹.

Men's place in teaching continued to be challenged through the second wave of feminism. A homophobic fear pervaded masculine society and teaching was seen as effeminate. Androcentric comments made during the first wave of feminism continued to surface at salary negotiation tables in that "teaching [could not] be a profession while women outnumber men". But at the same time, Coulter and Greig¹¹ noted that women were generally less motivated to move into leadership positions and more willing to accept lesser pay for a variety of reasons. Surveys indicated that women with a university degree were earning an average annual salary of \$11,363 while men with equal education earned an average of \$20,337. The differences in average wages were equally distinct for those with only a high school diploma: \$5,766 for women, \$12,085 for men²⁷.

Although discrimination continued to prevent women with aspirations for advancement from achieving it, the notion that women did not pursue those leadership positions because they did not aspire to them became insidious: during the 1970s "there [was] a prevailing view of women as passive, emotional and scatter-brained...[a characteristic that is] usually elaborated into a role expectation"¹⁰. High school guidance counselors perpetuated this erroneous belief by making course recommendations based on stereotypical assumptions about which careers would be appropriate, a significant practice to ensure "categories of gender, class, and race are reproduced in the school"²⁴. Gaskell's research determined that 84% of students in high school believe they are following educational and work paths of their own choosing yet "gender divisions in the school curriculum correspond to divisions in the labor force, just as class divisions do"²⁴. In this way, while students had the ability to make their own career choices in the 1970s, teachers tended to persuade them to a sexist course of study.

While "schooling can help a girl, relative to other girls, it is not effective in overcoming the group differences between males and females"²⁷. For example, women with business degrees worked clerical jobs, whereas men with business degrees worked in management. Gaskell describes how parents and friends often gave the erroneous information that there is high demand and easy opportunity for careers similar to their own, thereby perpetuating trends of gendered careers. After all, the consensus was if women aspired to high achievement, they would pursue

high achievement, regardless of discrimination¹⁰. Canadian society began to overcome some of these patterns and misconceptions in the third wave of feminism.

Post-Feminism? The Third Wave of Feminism

By the 1980s, women's work was concentrated in few occupational areas: "one-third of them are in clerical jobs; the rest are mostly in sales and service jobs and in teaching and nursing...[and] more likely than men to be at the bottom end of the hierarchy of responsibility and power"¹⁰. Over 41% of women were engaged in paid work¹² yet women continued to reflect the aspirations of their parents. Educational reformers increased their efforts to "address the goals, direction and strategies of feminist curriculum change"¹⁴.

Predictably, educational designers had a difficult time reaching consensus¹⁴: debates ensued about whether to modify existing curriculum to incorporate women's issues thereby enriching lessons, deconstruct and transform existing curriculum, or develop entirely new stand-alone courses. Several independent curriculum development teams began work across North America, like the New Jersey Project. This 1986 conference developed an inclusive curriculum that began as distinct women's studies and evolved into curricular integration of race, ethnicity, class and gender, introducing both content and methods. By 1996, the project grew to involve more than 100 faculty members in two- and four-year higher education institutions; it was followed by the Curriculum Mainstreaming Teaching Initiative that involved faculty from New Jersey, Maryland, Massachusetts, New York, Illinois, California and Tennessee.

History textbooks in British Columbia tended to add content about women's issue in sidebars and asides from the main text. This "filler feminism" trivialized the contributions of women and depicted a subservient, lesser role for girls¹². Elementary book authors were better at acknowledging the toil of women in *Canada, Building our Nation* but the secondary school texts then belittled their involvement with negative imagery of "women laughing and whispering together" during historical events¹². The Canadian provinces and territories commissioned text books that varied in their incorporation of women's issues, some providing broad coverage and others presenting women as 'larger than life' and 'tough as nails', a skewed representation difficult for girls to emulate.

In the 1990s, academic authors became more outspoken, using science to support the suggestion that "social inequalities have a biological basis or are genetically inherited and thus natural, right and good"²⁸. Women were caught between sexism and post-feminism, which already implied that the need for feminism was over. Shauna Pomerantz, Rebecca Raby and Andrian Stefanik²² note that constructs like 'Girl Power' and 'Successful Girls' create the image that social inequality no longer exists and the need for political action is over. Yet, as recently as 2008, the American Association of University Women indicated that girls "in North America continue to face sexual harassment and sexual violence, particularly in the early years of high school"²².

The struggle against sexism in high school continues today. Female teachers still report that they experience sexist innuendo and sexist comments from male colleagues, and that students portray women as sexual physical beings²⁹. Yet, through the 1990s girls outperformed boys on tests and college entrance examinations, and successfully competed with them for professional employment²². Academic researchers began to question why, after years of "feminist and

government interventions throughout the late twentieth century, boys are now struggling to keep up. Embedded in the Successful Girls discourse is thus a double form of gender reversal”²².

Stereotypes persist about mathematics being a male domain, augmenting other factors that research indicates influence girls’ success in the subject: the expectations teachers have about their students, students’ prior experiences in math, and the gender of their teachers^{30,31}. More troubling is “the school’s ‘hidden curriculum’ that teaches girls that they are less important than and subordinate to boys -- thus creating among girls an inner sense of inferiority that is self-silencing”³². Several longitudinal studies in various countries confirm this hidden curriculum and the specious perception of boys’ higher mathematical ability or talent, contradicted by test scores³³⁻³⁹. Girls’ ambitions for achievement, however, were apparently not affected by the hidden agenda prevalent in the STEM fields: Qing Li discovered that “women who initially aspired to science-related careers but then shifted to non-science interests a decade later had aspirations that remained as prestigious as their original, science-related aspirations (e.g., lawyer)”⁴⁰. In a later study, Li reported that while most teachers believe that education should be a “liberating and democratic influence” for students, they still “reinforce traditional behaviour and occupational plans for both males and females independent of where student interests or talent may lie, ...and at times they seem to actively discourage nontraditional (e.g., mathematical) female interests”³¹.

In her introduction to a series of articles on teaching, Susan Franzosa writes about a 1992 multinational conference in Vancouver, British Columbia, that attracted educators from the US, Canada and Australia who were interested in fostering “dialogue that would bridge the gap between academic research and school practices”, in order to assess “how feminist research could enrich the [public] school’s subject matter disciplines”¹⁴. Very different from the American consortia of the 1980s, at this conference full consensus could not be reached, with dissent arising even about the use of the term ‘enrichment’ in the conference invitation. When the attendees broke into smaller workgroups, they were eventually able to pursue their unique agendas. These disparate discussions led to valuable insights that are useful for “a wide range of educators, students of curriculum theory, and organizers of post-secondary and public school curriculum reform projects” in creating more inclusive curriculum¹⁴.

In the new millennium, Donatille Mujawamariya and Amani Hamdan conducted a review of the Ontario Science and Technology Curriculum to test it for diversity. They found that the curriculum met feminist criteria but lacking in aboriginal inclusivity¹⁵, reflecting the declining focus on women’s issues and the growing focus on the needs of indigenous peoples. Reviews are regularly conducted to ensure curriculum is inclusive because “students [are] more likely to succeed if their own racial, ethnic, and cultural identity is reflected in the classroom”¹⁵. Reviews of both the Ontario and British Columbia science curricula today rarely mention gender, only doing so to indicate that there were little or no differences in achievement between genders through the 1990s⁴¹. The implication is clear that gender is no longer an issue that needs to be reviewed.

At the same time, ongoing educational research explores the current state of students’ perceptions about their learning: Chenicheri Nair and Darrell Fischer’s transition study of rural schools in British Columbia, for example, found that women perceived learning environments more positively than their male classmates⁴². Both groups indicated that they found higher

education learning environments to be less favourable than those they experienced in high school, but no indication that women or men perceive any barriers to specific fields. Interestingly, Jennifer Shapka's study indicated that Canadian women respond negatively to the "perception of barriers to attaining one's educational goals"³³ in STEM because they perceive they are able to manage and maintain the balancing act between academic success and conforming to conventions of femininity⁴³. The message of society is that gendered careers no longer exist even though gender disparities clearly do exist in many professions.

The post-feminist constructs continue to change in the 2000s and girls now report seeing themselves as empowered amidst contradictory sexist experiences²¹:

[Girls in the study] spoke of themselves as empowered girls who have the world at their fingertips. But this feeling of optimism is contradicted by experiences of sexism both in and out of the school, and the belief that they will have to do better than boys throughout their lives just to be seen as equal.²¹

The messages of Girl Power and Successful Girls from the 1990s, that girls can do, be and have anything they want and that they are surpassing boys in the schools and work-places, "have made naming sexism in schools difficult for girls because they are now seen to 'have it all'...[and have made] cries of gender injustice appear not just unfounded but implausible"²². The post-feminist constructs mislead girls into thinking they shouldn't be experiencing the sexism that they are experiencing, so "the only person to blame when things go wrong is the girl herself"²². It is important to note that the constructs of gendered behaviour are expected of boys, too: for them, there is expected a cultivated behaviour that is aggressive, competitive and compulsorily heterosexual⁴³.

What does this mean for girls in physics?

Although curriculum design seems to finally be nearing a place of gender inclusivity⁴¹, teachers may in fact need some time to catch up. High school guidance counselors continue to encourage girls to pursue the quick path to clerical jobs²⁷ and teachers of mathematics continue to favour boys in the classroom³¹, so active research may be the best way to introduce new ideas to the adults who most influence the career choices of youth in high school.

Many of the larger engineering schools, the University of British Columbia, The University of Toronto and Waterloo University, reported record percentages of women in their first year classes in 2014¹. Interestingly, they all endorse outreach programs to high school and middle school girls. These external programs, like Go ENG Girl, and the Canadian Association for Girls in Science, CAGIS, are girls-only, activity-based programs led by young, vibrant, non-threatening and personable volunteer scientists. The programs follow up with past participants and report significant numbers are pursuing science careers⁴⁴.

The brunt of the feminist curriculum changes came out of the second wave of feminism. Most of those changes, however, integrated women's issues into the existing curriculum or added entire streams of women's studies courses and programs¹⁴. It is only in recent decades that new research has focused on how girls prefer to learn and what they need in order to feel safe to explore new and uncomfortable content^{32,43,45}. For example, Alison⁴⁶ determined through their

pilot program that girls prefer working in small groups with practical hands-on activities like poster projects, presentations and discussions. Based in the School of Engineering in the University of Tasmania, the researchers project goal was to attract girls in upper primary and secondary schools to engineering studies; in the process, they found which activities helped girls connect better to the physical sciences: “practical experiments and building things”⁴⁶.

In her mixed-gender study of science programs, Larissa Vingilis-Jaremko found that boys usually assume the active roles, a stereotype that is established as early as kindergarten⁴⁴. When girls are left to take on the passive role of note-taker, they disengage from the lessons, and lose both confidence and interest in STEM. This is not to say that single-sex schooling is the answer, as Jennifer Shapka⁴⁷ notes, because there are too many uncertainties surrounding the transition from single-sex to mixed-gender situations with the “reduced opportunities for cross-sex socialization” that may negate the benefits of studying physics in a same-sex classroom⁴⁷. Girls still tend to feel a decline in self-esteem and self-confidence during high school, both of which are predictors of decreased interest and competency in math^{33,34,48}. Shapka and Daniel Keating^{45,47} admit that many researchers have explored the benefits of single-sex and mixed-gender classrooms and schools, but controlling for multiple confounding variables, like socio-economic standing and prior achievement, has proven difficult. They recommend, therefore, that coeducational schools establish same-sex science classes to capture the best of both worlds: enabling girls to gain confidence and experience in physical sciences and learn mixed-gender socialization skills, which provide benefits in life-long success.

The factors remaining to be addressed are the forms of gender bias persisting in STEM classrooms. According to Acker and Oatley⁴⁸, the perception that boys dominate classroom interactions and monopolize technology continues to influence teacher behaviour. Boys apparently behave in this way for two main reasons: they are more self-confident than girls in high school and typical school practices reward gregarious behaviours⁴⁸. Claude Steele succinctly summarizes the challenge women face in having to overcome stereotypes in his 1997 article on achievement barriers to women in advanced quantitative areas:

To continue in math, for example, a woman might have to buck the low expectations of teachers, family, and societal gender roles in which math is seen as unfeminine as well as anticipate spending her entire professional life in a male-dominated world.⁴⁹

Finally, it is important to note that the academic researchers cited in this paper only discuss behaviour trends. Not all women had negative experiences in science classrooms or family-based gender role expectations, but significant proportions do⁵⁰⁻⁵². Perhaps if teachers take some time to learn about each student’s personal strengths⁵³, they will successfully transform their science classrooms into safe venues that inspire all students to freely explore and discover how to apply science to make the world a better place.

Next steps

This review presented feminist influences on curriculum over the past few decades in British Columbia. Educational change has been shown to improve the wellbeing of society by provoking discussions about issues and events that had major impacts on society⁵⁴. There is much that still needs to be done. Future changes to curriculum will generate new topics of debate depending on

how those changes manifest. Surveys of the perceptions of BC high school physics students today may reveal new information about how perceived barriers to careers in the physical sciences continue to evolve and comprises the basis of my doctoral research proposal. A survey of physics textbooks approved by the British Columbia Ministry of Education over this same temporal period may demonstrate how feminism has influenced and been influenced by science curriculum design. Possible changes to high school curriculum and lesson plans may provide opportunities to include more girls in scientific conversations; this may become clearer through the analysis of the participation rates of girls in science. An interesting outcome to watch for from such a quantitative data analysis would be whether correlations exist between feminized high school physics curriculum and participation rates of girls in post secondary physics programs.

Changes to education over the last century and a half have come about as a result of changes in the way society views itself. Recognition of gender inequality led to a critical review of teaching materials, curriculum documents and textbooks, that identified the perpetuation of biases^{10,21,22}. Adding commentary on the historical influences of women on the content, be it history or mathematics, and practice problem examples that reflect women's experiences teach students that the content is relevant to the future of boys and girls^{6,30}. But it is not enough to merely change the tools: teacher perceptions and behaviours must mirror the changing curriculum but take much longer to come about. This is another future project that may prove to be quite effective in improving the retention of women in the physical sciences.

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2015 ASEE Southeast Section Conference

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