

Sustainable Facilities & Infrastructure Training: Approaches, Findings, and Lessons Learned

Dr. Annie R. Pearce¹ and Ms. Sheila J. Bosch²

Abstract: Few existing knowledge resources, including conferences, workshops, training, or even engineering curricula provide a whole systems perspective on the challenge of realising a sustainable built environment. Those that do consider whole systems often fail to provide sufficient detail to permit practitioners to apply the concepts to their specific contexts. Further, those resources that seek a single resource spanning the range of sustainability issues from concept to technical details will find that no such resources currently exist. This paper describes a curriculum for continuing professional development training to fill these gaps with a training approach that combines university-level knowledge of sustainability theory, integrated problem solving, and systems analysis with the lessons and knowledge-based expertise of professional practitioners.

Different versions of the curriculum have been taught for organisations throughout the United States, ranging from government agencies to private Architecture/Engineering firms, as well as in Latin America. Each course is customised to highlight specific issues and concerns relevant to the context of the audience, and courses feature a series of interactive exercises that allow participants to explore barriers, risks, benefits, and specific sustainability implementation opportunities within their organisations. As a result of delivering this curriculum in adapted forms to over 350 graduate and undergraduate students (ranging from lecture series to laboratories to full-semester courses) and over 750 practising professionals from the USA and Latin America, the curriculum has provided not only the dissemination of sustainability knowledge to engineers and building professionals, but also has resulted in unprecedented research data about practitioner perspectives on sustainability strategies, technologies, and approaches to implementation.

This paper presents the structure and overall design of the curriculum on built environment sustainability, along with an overview of findings from data collection efforts during training and a summary of lessons learned from the training process. The paper concludes with a summary of recommendations for designing and delivering training on sustainability, along with a discussion of areas for future research and application stemming from these educational experiences.

1.0 Introduction

The concept of sustainability is gaining increased interest by decision makers as a potential solution for the myriad of global, regional, and local problems facing society in the late twentieth century. Even as developing nations struggle with issues of overpopulation, disease, and political conflict, developed countries such as the United States must balance problems such as infrastructure deterioration, pollution, and natural habitat loss with limited economic and physical resources to solve them. Sustainability offers a way of looking at problems on both

¹ Director, Sustainable Facilities & Infrastructure Program, Georgia Tech Research Institute; email: annie.pearce@gtri.gatech.edu

² Shackelford Fellow, Sustainable Facilities & Infrastructure Program, Georgia Tech Research Institute; email: sheila.bosch@gtri.gatech.edu

large and small scales, seeking to ensure that the needs of humanity are met in the present without endangering the potential for future human needs to be met. In the context of built facilities, sustainability can be defined as a state of the facility system marked by stability, both internal to the system as well as in terms of its context, into the foreseeable future. In terms of this definition, a sustainable facility is one that meets the needs and aspirations of its stakeholders without net negative impacts to the resource bases or ecosystems on which the system depends for its ongoing existence (Figure 1).

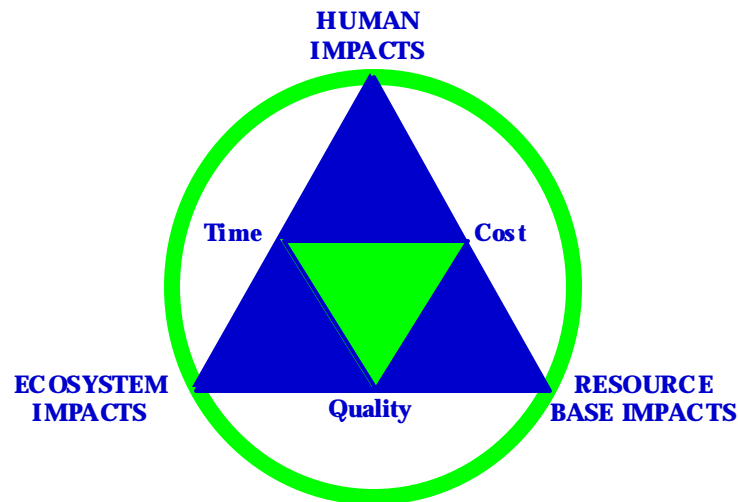


Figure 1: Parameters of Sustainable Facilities and Infrastructure (Pearce, 1999b)

Existing strategies for creating sustainable built facilities range from recycling construction and demolition waste, to designing for energy efficiency or healthy indoor environments, to integrating building systems for wastewater, heating, and other basic functions with existing ecosystems that perform those functions in nature. The domain of built facilities is ripe for implementing sustainability because not only are buildings vital to human existence in nearly all parts of the world, but also the built environment is one of the largest consumers of natural and manmade resources in the range of human endeavours. Built facilities also represent one of the most significant sources of negative impacts to the natural ecosystems on which we depend for life support. Traditional construction represents a profit-based approach to constructing the built environment, with minimisation of cost as the primary objective, maximising quality and performance as secondary objectives, and minimising negative environmental and other sustainability-related impacts as a tertiary objective. The shift to a sustainable built environment does not necessarily eliminate these primary objectives of traditional construction, but rather embeds them in a larger context of sustainability-related objectives.

To move toward sustainability, the Architecture/Engineering/Construction industry requires significant changes in the way it currently delivers facilities and civil infrastructure systems projects, and also, in the way manufacturers and vendors supply the building technologies, systems, products and materials it uses. Specifically, sustainability goals, concepts, principles, and guidelines need to be explicitly and systematically integrated in a project, at all stages of its life cycle, particularly the early funding allocation, planning and conceptual design phases. The challenges are: how can this be done? Where can one begin?

2.0 Structure and Design of Curriculum on Built Environment Sustainability

Georgia Tech's Sustainable Facilities and Infrastructure curriculum was conceived as an alternative to the state of the art in sustainability information. Our audiences include architects, engineers, contractors, builders, developers, planners, owners, and others who are interested in the concept of sustainability as it applies to the built environment. Why might they be interested in sustainability? A growing body of evidence suggests that sustainability can save them money, reduce their liability, attract new customers, open new markets, and increase their competitiveness over the long term (e.g., Hawken et al., 1999; Heerwagen, 2000; Romm & Browning, 1995; Von Weizsacker et al., 1998).

While many conferences, workshops, and publications are now available that deal with built environment sustainability (see Pearce & Vanegas, 2002 for an overview), few if any of these resources provide a whole systems perspective. Those that do consider whole systems generally fail to provide sufficient detail to permit practitioners to apply the concepts to their specific context. Further, those people who seek a single resource spanning the range of sustainability issues from concept to technical details will find that no such resources currently exist. Georgia Tech's Sustainable Facilities and Infrastructure curriculum was designed to meet the needs of built environment stakeholders who are seeking to make their facilities more sustainable. This series of courses is designed to fill these gaps with two significant sources of knowledge: 1) Georgia Tech's research-based knowledge of sustainability theory, integrated problem solving, and systems analysis; and 2) the lessons and knowledge-based expertise of professional practitioners. The training designed by Georgia Tech teaches course participants how to:

- Understand what sustainability means.
- Understand how sustainability might benefit their enterprises.
- Measure the sustainability of current and future projects.
- Understand the economic costs and benefits of this new approach.
- Work with diverse teams to make sustainability happen.
- Use state-of-the-art tools and resources for analysis, design, and problem solving.
- Prioritise potential strategies for improving project sustainability.
- Apply specific strategies to their projects.

Figure 2 shows the overall design of the curriculum series. The first three courses are designed to provide a common basis of understanding of the concept of sustainability and the general analysis tools and methods useful to all built environment decision makers seeking to implement sustainability. Following these three introductory courses, participants may take one or more of four discipline-specific courses that correspond to different phases of the project life cycle: design (SFI 410), construction (SFI 420), real estate development (SFI 430), and facility management, operations, and maintenance (SFI 440). Each of these courses is comprised of three primary parts:

- **Background, Teaming, Innovation, and Problem Solving**, in which participants learn how to break out of traditional project and discipline roles and methods;
- **Specific Strategies, Tools, Techniques, and Methods**, in which participants receive detailed information from industry experts on strategies that can be used to increase the sustainability of their facilities; and
- **Pulling the Pieces Together: Integrated Implementation**, in which participants learn how to select and integrate appropriate strategies for sustainability into an overall program for their facilities.

Sustainable Facilities & Infrastructure: Curriculum Design

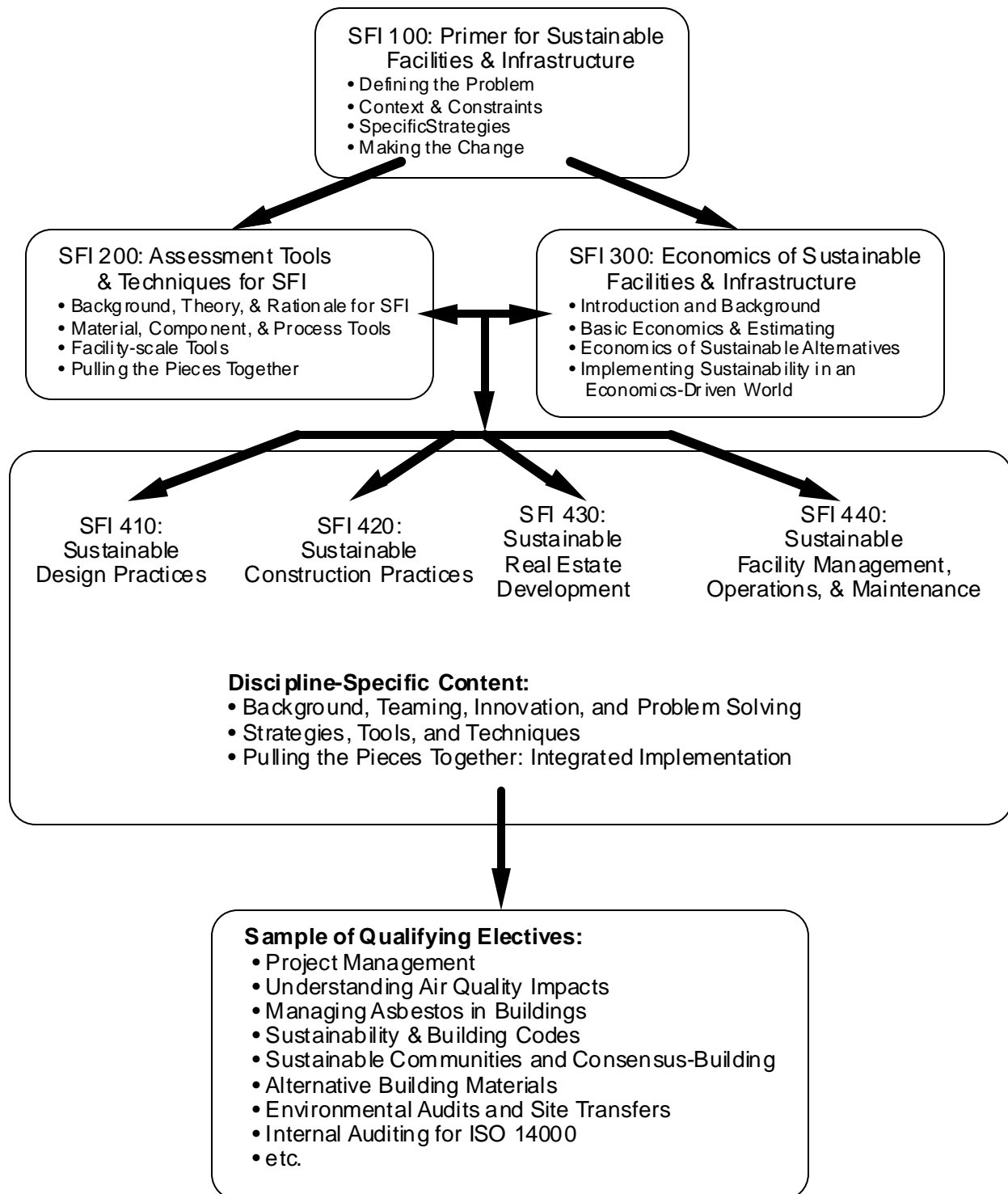


Figure 2: Structure of the SFI Curriculum (Pearce, 1999a)

Different versions of the curriculum have been taught for organisations throughout the United States and in Latin America, ranging from government agencies to private Architecture/Engineering firms. Each course is customised to highlight specific issues and concerns relevant to the context of the audience, and courses feature a series of interactive exercises that allow participants to explore barriers, risks, benefits, and specific sustainability implementation opportunities within their organisations. As a result of delivering this curriculum in adapted forms to over 350 graduate and undergraduate students (ranging from lecture series to laboratories to full-semester courses) and over 750 practising professionals from the USA and Latin America, the curriculum has provided not only the dissemination of sustainability knowledge to engineers and building professionals, but also has resulted in unprecedented research data about practitioner perspectives on sustainability strategies, technologies, and approaches to implementation. The following section describes findings from these courses.

3.0 Overview of Findings from Data Collection during Training

One unique aspect of Georgia Tech's curriculum offerings is the integration of active learning exercises as part of each course during which participants generate data ranging from qualitative reactions to concepts presented, to execution plans for sustainability implementation in their organisations. Consistent execution of the same exercises over multiple audiences provides a rich data set that reveals a great deal about how practitioners perceive the risks and benefits of sustainability for their organisations, as well as the barriers and next steps that must be incorporated as part of implementation. Table 1 lists examples of the kinds of exercises that have been used not only as teaching tools, but also as sources of research data about individual and organisational implementation of sustainability concepts in practice. The results of several exercises are presented in the following subsections as a means to illustrate the spectrum of data that has been collected from participants over the course of nine separate training events where exercises were consistently applied. Data collected ranges from textual statements submitted via participant worksheets, to audience votes, to completion of self-assessment checklists.

3.1 Most Implementable LEED™ Points

The Leadership in Energy and Environmental Design (LEED™) Green Building Rating System is the de facto rating system for sustainable facilities in the United States. Georgia Tech's courses use the LEED™ Rating System as a framework to help participants prioritise how they would like to start implementing the strategies and technologies about which they have learned in the course. LEED™ is a self-assessment tool developed by the U.S. Green Building Council³ for new and existing commercial and industrial facilities. Points can be earned in five categories (sustainable sites, energy, water, materials and resources, and indoor environmental quality). In this exercise, following a two-hour overview of the LEED™ rating system, participants are asked to identify the top three specific LEED points they believe would be the most easy to implement in the kinds of projects with which they are typically involved. Figure 3 shows how these data can be normalised and visually represented to compare participant perceptions about the applicability of individual strategies and goals in the contexts of their project environments. The example shown applies to the Materials & Resources category, which contains 13 credits and one prerequisite.

³ For more information on the LEED™ Green Building Rating System, see <http://www.leedbuilding.org>.

Table 1: Active Learning Exercises

	Topic (Module)	Exercise	Purpose
1	Implementation Challenges	Small group brainstorm and round robin on most likely challenges to implementation and risks and rewards of sustainability	To assess participants' perceptions about sustainability for capital projects following an introduction to the concept and relevant policy
2	The LEED™ Green Building Rating System	Participant vote (individual selection of top three points for each category) and discussion on most implementable LEED™ points for capital projects	To identify and prioritise low-hanging fruit for increasing sustainability of their organisation's capital projects
3	Project Strategies in the Context of the LEED™ Green Building Rating System	Barriers to, benefits of, and next steps for implementing top-ranking points for project scenarios (Small group discussion; report back to group)	To identify challenges, motivations, and specific products, design features, and technologies that are most appropriate for achieving LEED™ points in the context of capital projects
4	Implementation Challenges Revisited	Individual brainstorm and reporting (via round robin or vote on index cards) on most likely challenges to implementation and barrier breakers that can be used to overcome them	To assess participants' perceptions about sustainability for capital projects following an overview of project techniques and opportunities; to assess whether these perceptions have changed as a result of introduction to technologies, strategies, and examples
5	Barriers and Best Practices	Barrier Breaker Matrix and Checklist (self-assessment worksheet completed by individuals)	To facilitate individual tracking of most appropriate best practices that could be applied to surmount implementation barriers on capital projects
6	Overcoming Barriers to Sustainability Implementation	Action Items Input Sheet (Input sheet completed and submitted by individuals)	To identify action items that participants feel their organisation must take to increase the sustainability of their capital projects, along with benefits, resources required, actions, and target dates
7	Overcoming Barriers to Sustainability Implementation	Personal Commitment Input Sheet (Input sheet completed and submitted by individuals)	To identify specific commitments that each participant is willing to undertake to increase the sustainability of capital projects

3.2 Barriers to Implementing Sustainability on Capital Projects

A second exercise conducted in multiple training environments has resulted in data that led to the development of a complementary course on sustainability implementation for organisations. This exercise involves capturing participant reactions to sustainability strategies and technologies to which they have been introduced in the first day of training. Participants complete a worksheet in which they identify anticipated barriers to sustainability implementation on their capital projects. For each listed barrier, they are required to list at least two tactics for overcoming that barrier. Over the course of nine training events, these barriers and barrier breakers have been compiled into a matrix showing the top ten most frequently mentioned barriers correlated with best practice barrier breakers suggested to overcome them. Table 2 shows the matrix that resulted from participant inputs. This matrix forms the core of the curriculum for the follow-on sustainability implementation course, which has been offered in multiple configurations in five separate forums to date.

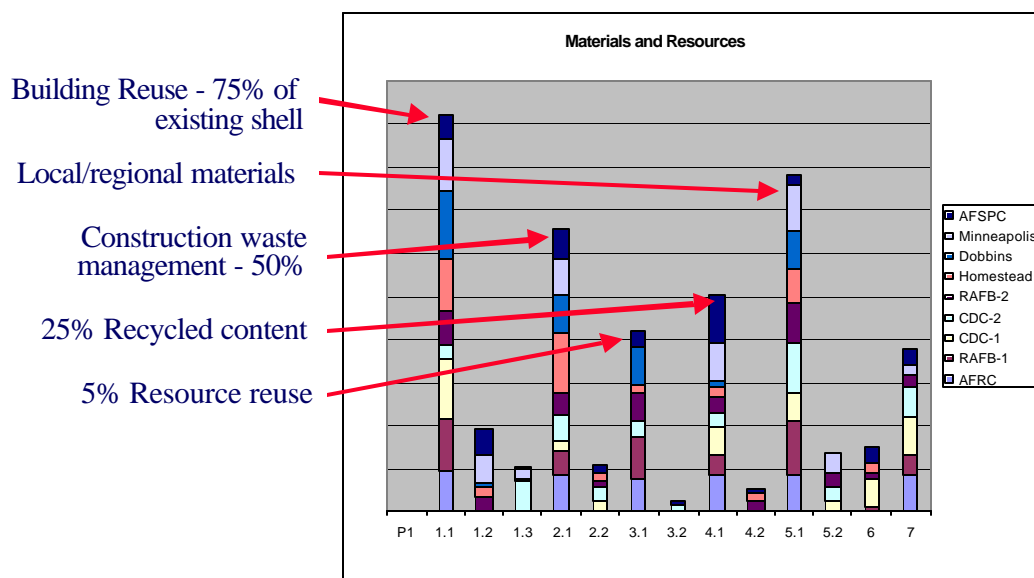


Figure 3: Example of Visual Comparison of LEED™ Point Votes for Materials Credits

4.0 Conclusions

With the growing awareness of potential benefits afforded by sustainability to the stakeholders of capital projects, the anticipated need for comprehensive training on this topic is great. This paper describes the design and results of implementing a whole-systems curriculum that addresses all stakeholders of the built environment and all life cycle phases of built facilities. The following subsections describe lessons learned from implementing this curriculum across multiple audiences, and identify areas for future research and application of this comprehensive educational approach.

4.1 Lessons Learned and Recommendations

Primary lessons learned about the curriculum came from course participants themselves. Table 3 lists clusters of action items that were outcomes of the training showing what participants themselves believed were the most important points to be taken from the training.

Table 3: Representative Participant Action Items Identified During Training

Training/Education/Awareness
“Educate all personnel involved in building process on sustainability concepts.”
“Need to create a greater awareness of sustainability concepts by providing additional training at all levels and in all departments.”
“Report wins and provide cross-feed forums on successes”
Adopt sustainability policies and tools
“Incorporate LEED™ scores for all major projects”
“Adopt sustainable project procedures, technologies, tools, and methods and include them in all project language”
“Create an organisational policy or vision statement that includes sustainability goals and objectives as a major part”
“Incorporate sustainability criteria into the required SOW and evaluation of A/E firms and their submittals”
Provide management support and commitment
“Headquarters [needs to] enforce the incorporation of sustainability”
“Total commitment from 3 stars down”
“A commitment to a different approach to projects which will allow sustainability to be implemented, e.g., de-emphasise completion schedule and cost as guiding factors; institute LCA and make decisions based on these analysis; more flexibility in administrative procedures to implement new ideas”
“Management must take the first step in sustainability”
Identify opportunities and establish priorities
“Identify areas where sustainability is achievable now”
“Set well-defined sustainability goals”
“Make sustainability a priority by including in vision and mission”
“Find at least one sustainable item to implement in each funded project”
“Program and design a prototype green project”
Establish a Green Team
“Establish a team to initiate and champion the sustainability implementation process”
“Create a small working group within the organisation to focus on implementing sustainability within all actions”

Based on these action items, recommendations for education providers seeking to implement comprehensive curricula for built environment stakeholders include:

- For training to be effective, all stakeholders involved in the capital project process must be involved, including upper management.
- Follow-up with action items developed during training is essential to show organisational commitment to sustainability implementation.
- Training effectiveness at the professional development level can be inhibited by lack of organisational resources and policies that specifically address sustainability.

- Training effectiveness is enhanced by including clear metrics of sustainability that provide participants with a framework to prioritise potential actions.
- Creating workgroups and teams dedicated specifically to facilitating organisational change can increase the impacts of sustainability educational programs as a whole.

Overall, the effectiveness of training at the professional development level is strongly affected by co-ordination and compatibility with the norms, procedures, and constraints of the organisation whose participants are being trained. Likewise, including all stakeholders, from designers to procurement personnel to management, provides a cross-disciplinary dynamic to training that can help to identify potential challenges *before* implementation begins and thus avoid problems that might otherwise derail the sustainability implementation process.

4.2 Areas for Future Research and Application

Key areas for future research that have emerged as a result of the deployment of this curriculum centre around measuring the impacts of different approaches to professional development training. The learning exercise-based data collection efforts discussed in this paper are examples of opportunities to systematically and consistently sample the perspectives of practitioners who participate in the training, and could be used to assess trends in sustainability adoption across disciplines, industries, and organisations. Georgia Tech's sustainable facilities and infrastructure curriculum continues to evolve over time and be applied in different organisational contexts and format, based on the participant feedback and learning needs identified as part of participant exercises. The overall curriculum design is portable and can be adopted and adapted to built environment stakeholder audiences both in the United States and abroad. Active learning exercises are key to identifying improvement opportunities within the curriculum and successfully adapting it to multiple audiences.

5.0 References

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