

**AC 2010-35: COMBINED BS/MS PROGRAMS IN MECHANICAL ENGINEERING:
A BENCHMARK STUDY**

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Combined BS/MS Programs in Mechanical Engineering: A Benchmark Study

Abstract

The G.W. Woodruff School of Mechanical Engineering at the Georgia Institute of Technology (Georgia Tech) started offering a combined BS/MS degree in fall 2001. This program allows meritorious undergraduate students, desiring graduate studies beyond the bachelor of science degree, an accelerated path towards the granting of the master of science degree. Students may pursue a thesis or non-thesis option in completing the MS degree.

Since inception of this program, a majority of the BS/MS students have chosen the non-thesis (course work only) option. A recent goal of this BS/MS program in mechanical engineering at Georgia Tech is to increase the number of students choosing the thesis, or research, option. This paper compares BS/MS programs in mechanical engineering at Georgia Tech and its peer institutions. The purpose is to analyze how various academic institutions address this issue (minority of BS/MS students doing a thesis), to collect lessons learned, and to provide recommendations that could promote an increase in thesis participation in BS/MS programs in the future.

Introduction

Engineering curricula in the United States has typically changed very little in the past 30-50 years. Most changes that did occur typically have been in the form of course redesign and new courses replacing existing ones. However, there is a growing call for fundamental changes in the engineering curriculum to address the dramatic technological challenges in fields such as healthcare, energy, and security, and to continue to develop and maintain the appropriate infrastructure to support such new areas of research.

A recent development has been the creation of combined BS/MS programs within engineering disciplines. The BS/MS program is usually defined as an accelerated curriculum geared towards providing both degrees faster than if pursued sequentially. This is a relatively new approach in American universities, generally observed since the late 1980's, though in other parts of the world such as Europe, the first engineering degree has always required a minimum of five years of study and been considered equivalent to the MS degree.

These BS/MS programs vary in their details at different academic institutions. For the most part, they offer the qualified student:

- 1) the possibility to earn their BS and MS degrees in less time than it would take to pursue both degrees separately, and
- 2) the opportunity to deepen and diversify their technical and professional skills, which will help make them more competitive and marketable in the global marketplace.

As BS/MS programs grew more popular with both students and faculty, many different programs have reported on their implementation and lessons learned¹⁻⁸.

In reviewing these sources, it is clear that each institution, and even programs within an institution, may implement combined BS/MS programs quite differently. The focus of this paper will be on mechanical engineering programs.

One goal of this paper is to assess how Georgia Tech and its peer institutions market and develop BS/MS programs. Since inception of the Georgia Tech program, a majority of the BS/MS students have chosen the non-thesis (course work only) option. A recent goal of the BS/MS program in mechanical engineering at Georgia Tech is to increase the number of students choosing the thesis, or research, option. The main reason for this goal is that BS/MS students are our top students, and having more of them pursue the thesis option would help strengthen our School's research program (resulting in, potentially, increased peer-reviewed publications and funding). There is also hope that this will help encourage more of our top students to consider the Ph.D. degree, and ultimately, an academic career.

This paper compares BS/MS programs in mechanical engineering at Georgia Tech and its peer institutions. The purpose is to analyze how various academic institutions address these issues, to collect lessons learned, and to provide recommendations that could promote an increase in thesis participation in BS/MS programs in the future.

Background

The combined bachelor's degree and master's degree (BS/MS) in mechanical engineering at Georgia Tech started in fall 2001. At the same time, BS/MS programs began in Materials Science and Engineering (MSE), and later came to be adopted in almost every engineering school at Georgia Tech, except in the H. Milton Stewart School of Industrial and Systems Engineering and the Wallace H. Coulter Department of Biomedical Engineering. Only a small number of students choose the combined BS/MS program. Table 1 shows the average percentage of participants at slightly over one percent of the total enrolled population of mechanical engineering undergraduate students at Georgia Tech.

Academic Year	Total Mech Engr Undergrad Enrollments	Total Mech Engr BS/MS Enrollments	Percentage of BS/MS students
AY 2006-2007	1571	20	1.27%
AY 2007-2008	1593	17	1.07%
AY 2008-2009	1650	23	1.39%

Table 1. Percentage of BS/MS students, Mechanical Engineering, Georgia Tech, 2006-2007

Students can pursue either a thesis or non-thesis option in completing the master's portion of the BS/MS degree. Through the fall of 2008, 44.4% of students in the program chose the thesis option (Figure 1).

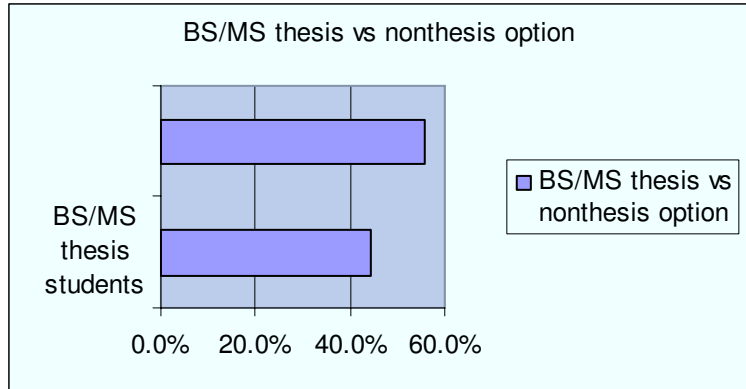


Figure 1. Percentage of BS/MS students choosing thesis versus non-thesis option

Upon initiation of the BS/MS program in mechanical engineering, the goal was to retain the top undergraduate students at Georgia Tech to pursue graduate studies. The hope was that many of these students could be introduced to research, work closely with a faculty member, and preferably choose the master’s thesis option. In individual cases, the desire was also to possibly motivate these intellectually talented students to achieve the doctoral degree.

The objective to encourage the BS/MS student population to choose the MS thesis option is being achieved quite well with nearly 50% of the participants doing so. Our desire is to further increase this percentage in future years. In assessing our BS/MS program, we want to achieve continuous improvement in other areas as well. One method of gaining insight for opportunities to improve is to examine similar programs at peer institutions. This was the motivation for undertaking the benchmark study presented in this paper.

Conduct of the Study

The authors selected schools for this study from a list of peer institutions maintained by the Georgia Tech Office of Institutional Research and Planning, <http://www.irp.gatech.edu/Peer%20Institutes.html>. Nineteen schools were investigated to obtain a sample size of ten schools with combined BS/MS programs. This figure implies that about one half of our current peer mechanical engineering programs have a dual bachelor and master’s degree program. Table 2 shows a list of the schools included in our study.

GT Peer Institution with BS/MS Programs
Stanford University
Johns Hopkins University
Carnegie Mellon University
Virginia Tech
Purdue University
University of Michigan
University of Illinois at Urbana-Champaign
Northwestern University

University of California-Berkeley
University of Florida

Table 2. Georgia Tech Peer Institutions included in study with BS/MS Programs

Because we were unable to gather any information from the last institution in Table 2, the University of Florida’s Department of Mechanical and Aerospace Engineering, the Iowa State University was chosen to replace it.

A set of common questions were developed for inclusion in this study and are available in Appendix A. Personal telephone conversations and web sites were used in acquiring the data.⁹⁻²³

Standards for Admission Comparisons

Comparisons were made between the admission standards for combined BS/MS programs and conventional master’s degree applicants. As shown in Table 3, the GPA requirements for entry into the BS/MS programs are generally higher. Table 4 shows in some cases that fewer letters of recommendation are required for BS/MS applicants and the requirement to take GRE exams is sometimes waived.

School	BS/MS GPA Requirement	BS/MS GPA Guideline	Conventional MS GPA Guideline
Georgia Tech	higher	≥ 3.5	≥ 3.0
Stanford University	higher	≥ 3.5	unspecified
Johns Hopkins University	same	unspecified	unspecified
Carnegie Mellon University	same	≥ 3.0	≥ 3.0
Virginia Tech	higher	≥ 3.5	≥ 3.2
Purdue University	same	≥ 3.2	≥ 3.2
University of Michigan	higher	≥ 3.6	≥ 3.2
University of Illinois at Urbana-Champaign	higher	≥ 3.7 (invitation only)	≥ 3.25
Northwestern University	higher	≥ 3.0 (≥ 3.5 -no LORs reqd)	≥ 3.0
University of California-Berkeley	higher	≥ 3.5	≥ 3.0
Iowa State University	higher	≥ 3.5	≥ 3.2

Table 3. GPA Comparison for BS/MS versus conventional programs

School	Required Letters of Recommendation (LOR)		GRE Exam Required?	
	BSMS	Conventional MS	BSMS	Conventional MS
Georgia Tech	1	3	no	yes
Stanford University	2	3	yes	yes
Johns Hopkins University	3	3	no	no
Carnegie Mellon University	3	3	yes	yes

Virginia Tech	2	3	no	yes
Purdue University	2	3	no	no
University of Michigan	3	3	no	no
University of Illinois at Urbana-Champaign	3	3	no	yes
Northwestern University	2 (none for GPA ≥ 3.5)	2	no	yes
University of California-Berkeley	1	≥ 3	no	yes
Iowa State University	3	3	no	no

Table 4. LOR and GRE Comparison for BS/MS versus conventional programs

Other differences in BS/MS versus traditional separate degrees

The most cited reasons for students to apply to a BS/MS program is the ability to start graduate course work during undergraduate studies, and the ability to accelerate the completion of their master's degree. Fifty percent of the schools included in this study allow students to double count course work toward both the bachelor's and the master's degree. The degree to which this double counting takes place varies as shown in Table 5.

School	# of courses allowed to be double counted toward both BS and MS degree
Georgia Tech	2 out of 10
Stanford	2 out of 10 (20%) [2 out of 8 for thesis option]
Johns Hopkins University	none
Carnegie Mellon University	none
Virginia Tech	4 out of 10 (40%) [4 out of 7 for thesis option]
Purdue University	4 out of 10 (40%) [4 out of 7 for thesis option]
University of Michigan	3 out of 10 (30%)
University of Illinois at Urbana-Champaign	none
Northwestern University	none
University of California-Berkeley	none
Iowa State University	none

Table 5. Double counting of course work allowing in BS/MS programs

With regard to financial aid, none of the schools included in this study promised funding for BS/MS students. In some cases students were allowed to compete for Graduate Research Assistant (GRA) and Graduate Teaching Assistant (GTA) positions. Clearly, whether or not the

student obtains some type of financial support impacts his/her decision to pursue the master's degree – and to do a thesis.

Thesis versus non-thesis option

The programs studied in this paper, along with other BS/MS programs reviewed in the literature, have various philosophies as to whether students are encouraged to choose the thesis option or non-thesis option for the master's degree portion of their studies. Some schools offer only the non-thesis option (for example, Carnegie Mellon University); some offer only the thesis option (for example, University of Illinois at Urbana-Champaign); and some offer both (for example, Georgia Tech or the Iowa State University).

Programs that allow only the non-thesis option for the graduate portion of the BS/MS studies have some common features:

- Students may include classes from disciplines such as law or business for a broader learning experience. In this case, the MS degree is usually viewed as a terminal degree.
- The time to graduation is well-defined and consistent for all students.
- Students may be selected into the program as late as their senior undergraduate year (depending on how many courses are allowed to be double-counted).
- Advising, tracking and mentoring the student is easier.

Programs that allow only the thesis option for the graduate portion of the BS/MS program usually have the following features:

- The time to graduation varies depending on the thesis research project, the faculty advisor, and the student.
- Students are often selected as early as possible (in the first year of undergraduate studies sometimes, based on AP credits) and highly encouraged to do as much undergraduate research as possible, so as to get a head start on their MS thesis.
- Prior to the graduate portion of their studies, students in financially difficult situations tend to prefer co-ops and internship positions because of the lack of significant funding for undergraduate research.
- Finding an appropriate faculty thesis advisor can be complex. Research-intensive universities often place a priority on placing PhD students, rather than MS thesis students, in conducting graduate research. Schools without doctoral programs sometimes have few faculty members engaged in research programs robust enough to advise and financially support MS thesis students.
- At the schools we studied, only a small percentage of BS/MS students ($\leq 5\%$) chose to continue on to complete the PhD degree.

Programs that allow both the thesis and non-thesis MS options have both sets of features depending on the student's decision.

Results and Conclusions of this study

The purpose of this paper was to analyze how various academic institutions address combined BS/MS program issues. In conducting this study, the BS/MS programs were found to have much more diversity in their implementation than expected.

The original goal of this work was to find if other institutions had good systems in place, or strategies, to encourage their best students to consider doing a thesis. Lessons learned were collected. There does not seem, however, to be a good consensus or method to increase the number of students who do choose the thesis option when it is available to them.

Overall, the non-thesis MS is usually successful and attractive to students who like predictable time to completion of graduate studies. Students also enjoy the versatility of the program and value to employers.

The thesis MS is more complex to implement, but systematic mentoring and early exposure to undergraduate research are particularly helpful.

Recommendations to increase BS/MS thesis option in the future

Several actions are currently being taken with regard to the Georgia Tech mechanical engineering goal of increasing BS/MS students choosing the thesis research option. The brochure advertising the program is being revamped. Web page references are being reworked to emphasize the benefits of the thesis option. Special attention is being taken to

- 1) de-emphasize time requirement,
- 2) emphasize assistantship funding – stipend and tuition waiver,
- 3) emphasize academic richness of thesis research experience in all communications regarding the BSMS program.

A future assessment is planned in 3 to 5 years to determine if, and how well the goal of increasing the percentage of BS/MS students choosing the thesis option is achieved.

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Appendix A

Questions:

1. Do you have a BSMS program?

2. If so, what are its requirements? Minimum GPA, essay, letter(s) of recommendation (how many)...? Do you require GRE?
3. Are your admission standards different for your BSMS applicants? Are there items (GRE scores, etc.) that are required for normal grad student applicants, but not for BSMS applicants.
4. Do you advertise the BSMS program in terms of its duration, i.e., 'five-year program'?
5. How soon can your BSMS students apply for the program? What's the latest they may apply? (e.g. min # hours/max #hour or only during 1st semester of junior year)
6. Do you allow your students to double count any of their course work toward both the BS and the MS degree? If yes, how much double counting?
7. Do you promise any type of funding for your BSMS students? (GRA/GTA, etc.)
8. Do you try to encourage your BSMS students to pursue MS Thesis rather than Non-Thesis? If so, what methods do you use? Do you feel successful?
9. What (rough) percentage of your BSMS students pursue the Thesis option? How many go on to pursue a PhD?
10. Do you have a BS-PhD? If so, what is its duration? Requirements?