

**Software Internationalization:  
A Framework Validated Against Industry  
Requirements for Computer Science and  
Software Engineering Programs**

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Thesis Defense

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# Thesis Defense Outline

- **Introduction**
- **Research Question**
- **State of Education of Internationalization**
- **Industry Survey Questionnaire**
- **Conclusion**

# Introduction

What is Software Internationalization?  
Is Software Internationalization Important?  
Are Students Adequately Learning?  
Are Industry's Requirements Being Met?

## What is Software Internationalization?

- **Software Internationalization (i18n)**
  - The process of producing an application that can be localized for a particular country, without any changes being made to the program code <sup>[8]</sup>
- **Localization (l11n)**
  - The process of adapting software for a particular geographical region or locale <sup>[9]</sup>
- **Globalization (g10n)**
  - The process of making all the necessary technical, financial, managerial, personnel, marketing and other enterprise decisions to facilitate international business <sup>[9]</sup>

## Is Software Internationalization Important?

- **One study concluded that ...**
  - **Software internationalization is one of the most important aspects of software development with respect to the globalization process in the world** <sup>[10][11]</sup>
- **Revenues**
  - **Top 100 United States software companies**
    - Constitutes more than half of the revenues <sup>[5][13]</sup>
  - **2006 Global Fortune 500**
    - Yield a revenue of \$5.9 trillion, profits of \$365 billion <sup>[14]</sup>
- **Benefits** <sup>[5]</sup>
  - **Brings huge savings**
  - **Increased revenues and profits**
  - **Shorter product-time to market**

## Are Students Adequately Learning?

- **2001 – ACM and IEEE Computing Curriculum**
  - Address “the need to develop implementation models that are international in scope and could be practiced in universities around the world” [1]
- **The increasing connectivity through the internet and a move towards a global economy places ...**
  - Software internationalization an important concern [2]
  - The knowledge is essential for companies seeking to go global or who are already global [10]
  - Clear shortage of persons for entry-level positions [3]
  - Increasing demand for such knowledge over time [1]

## Are Industry's Requirements Being Met?

- **Eric Brechner** [4]
  - Director of Microsoft Development Training
  - Wrote “Things they would not teach me of in college”
  - “ A course on globalization and accessibility is **long overdue** on college campuses. It is **embarrassing** to take graduates from a college with a diverse student population and have to teach them how to write software for a diverse set of customers. It should be part of introductory software development. Anything less is **insulting** to students, their family, and the peoples of the world.”

# Research Question

Research Question  
Answering the Research Question



# Research Question

- **Is there a framework for software internationalization that has been validated against industry requirements?**

# Research Question

## Answering the Research Question

- **Is there a framework for software internationalization that has been validated against industry requirements?**
- **Develop a Framework**
  - **A standard set of skills and knowledge that could be taught by any knowledgeable instructor<sup>[5]</sup>**
  - **Complete, consistent, modifiable, and traceable<sup>[37]</sup>**
  - **Communication between academia and industry that could serve as a common reference point <sup>[5]</sup>**

# State of Education for Internationalization

Requirements Problem

Educational Architectural Models

Set of Requirements from Literature Review

# State of Education for Internationalization Requirements Problem

- **Requirement** <sup>[37]</sup>
  - A statement of a customer need or objective, or of a condition or capability that a product must possess to satisfy such a need or objective. A property that a product must have to provide value to a stakeholder.
- **Characteristics of an excellent requirement are**
  - complete, correct, feasible, necessary, prioritized, unambiguous, and verifiable <sup>[37]</sup>
- **Overarching Requirement**
  - To provide qualified computer science and software engineering students with the knowledge of software internationalization to the industry

# State of Education for Internationalization

## Educational Architectural Models

- **Integration into Existing Courses**
- **Develop an Entire Course**
- **Study Abroad for Experience**

# State of Education for Internationalization Educational Architectural Models

- **Integration into Existing Courses** <sup>[1]</sup>
  - **Most programs employ this model** <sup>[1]</sup>
  - **See how topics work with other fields** <sup>[39]</sup>
  - **Not discussed in-depth or applied to projects** <sup>[1]</sup>
- **Develop an Entire Course**
- **Study Abroad for Experience**

# State of Education for Internationalization

## Educational Architectural Models

- Integration into Existing Courses
- **Develop an Entire Course** <sup>[1]</sup>
  - **Undoubtedly rare to adopt this model** <sup>[33][3]</sup>
  - **Topics are discussed in depth or applied to projects** <sup>[1][10]</sup>
  - **Not feasible or cost-effective** <sup>[3]</sup>
- Study Abroad for Experience

# State of Education for Internationalization

## Educational Architectural Models

- Integration into Existing Courses
- Develop an Entire Course
- **Study Abroad for Experience** <sup>[1]</sup>
  - Integrate software internationalization first-hand <sup>[1][33]</sup>
  - Understand the cultural issues, practices, and laws
  - Not feasible or cost-effective <sup>[1]</sup>



# State of Education for Internationalization

## Set of Requirements

- **Definitions and Standards**
- **Development Practices**
- **Translation and Documentation**
- **Social Responsibilities and Ethics**
- **Cultural Concerns**

# State of Education for Internationalization

## Set of Requirements

- **Definitions and Standards**
  - **Definitions:** i18n, l11n, g10n
  - **Standards:** Unicode, CLDR, ISO, W3C, LISA
  - **Case Study:** Majority were unfamiliar
- **Development Practices**
- **Translation and Documentation**
- **Social Responsibilities and Ethics**
- **Cultural Concerns**

# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- **Development Practices**
  - “Learn by Doing”
  - ICU Project
- Translation and Documentation
- Social Responsibilities and Ethics
- Cultural Concerns

# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- Development Practices
- **Translation and Documentation**
  - **Direction**
  - **Sorting**
  - **Date and Time**
    - Example: 02/03/09
  - **Number and Currency**
    - Example: \$1,234.56
- Social Responsibilities and Ethics
- Cultural Concerns

# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- Development Practices
- **Translation and Documentation**
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# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- Development Practices
- Translation and Documentation
- **Social Responsibilities and Ethics**
  - ACM Software Engineering Code of Ethics
  - GILT Industry Ethics by LISA
- Cultural Concerns

# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- Development Practices
- Translation and Documentation
- Social Responsibilities and Ethics
- **Cultural Concerns**
  - **Colors** [Table 1]
  - **Visual Elements**
  - **Noise Elements**
  - **Laws and Customs**

# State of Education for Internationalization

## Set of Requirements

- Definitions and Standards
- Development Practices
- Translation and Documentation
- Social Responsibilities and Ethics
- **Cultural Concerns**
  - **Colors** [Table 1]
  - **Visual Elements**
  - **Noise Elements**
  - **Laws and Customs**



# Industry Survey Questionnaire

Design  
Results and Analysis

# Industry Survey Questionnaire Design

- **Goals**
- **Summary of Hypotheses**
- **Data Observations and Hypothesis Tests**
- **Subjects**
- **Survey Design and Procedure**

# Industry Survey Questionnaire Design

- **Goals**

- Ensure that the requirement of our industry customers, which is to hire computer science and software engineering students who are knowledgeable in software internationalization, is **complete** and **feasible**.
- Provide a framework validated by the industry
- Provide a framework that is portable and standardized

- Summary of Hypotheses

- Data Observations and Hypothesis Tests

- Subjects

- Survey Design and Procedure

# Industry Survey Questionnaire Design

- **Goals**
- **Summary of Hypotheses** [Table 2]
  - **Likert scale**
    - Determines how a respondent feels strongly about a particular statement or question [57]
    - Options from Strongly Agree, Somewhat Agree, Neither, Somewhat Disagree, Strongly Disagree
- **Data Observations and Hypothesis Tests**
- **Subjects**
- **Survey Design and Procedure**

# Industry Survey Questionnaire Design

- Goals
- Summary of Hypotheses
- **Data Observations and Hypothesis Tests**
  - Check for Sample Size
  - Calculate Averages
  - Test for Equal Proportions
  - Test for Significant Majority
- Subjects
- Survey Design and Procedure

# Industry Survey Questionnaire Design

- Goals
- Summary of Hypotheses
- Data Observations and Hypothesis Tests
- **Subjects**
  - ACM, LISA, Unicode Consortium
  - Industrial Advisory Board
  - Demographics
- Survey Design and Procedure

# Industry Survey Questionnaire Design

- Goals
- Summary of Hypotheses
- Data Observations and Hypothesis Tests
- Subjects
- **Survey Design and Procedure**
  - Tools for gathering data
  - Human Subjects Committee
  - Survey Questionnaire
  - Procedure

# Industry Survey Questionnaire Response Rate

**1,000 companies were  
successfully contacted**

**361 recorded responses**

**278 valid responses**



# Industry Survey Questionnaire

## Participating Companies

Siemens IBM Rosetta Stone AMD

Expedia Google Opera Microsoft LLNL

Trend Micro SAP

Symantec **148** Yahoo!

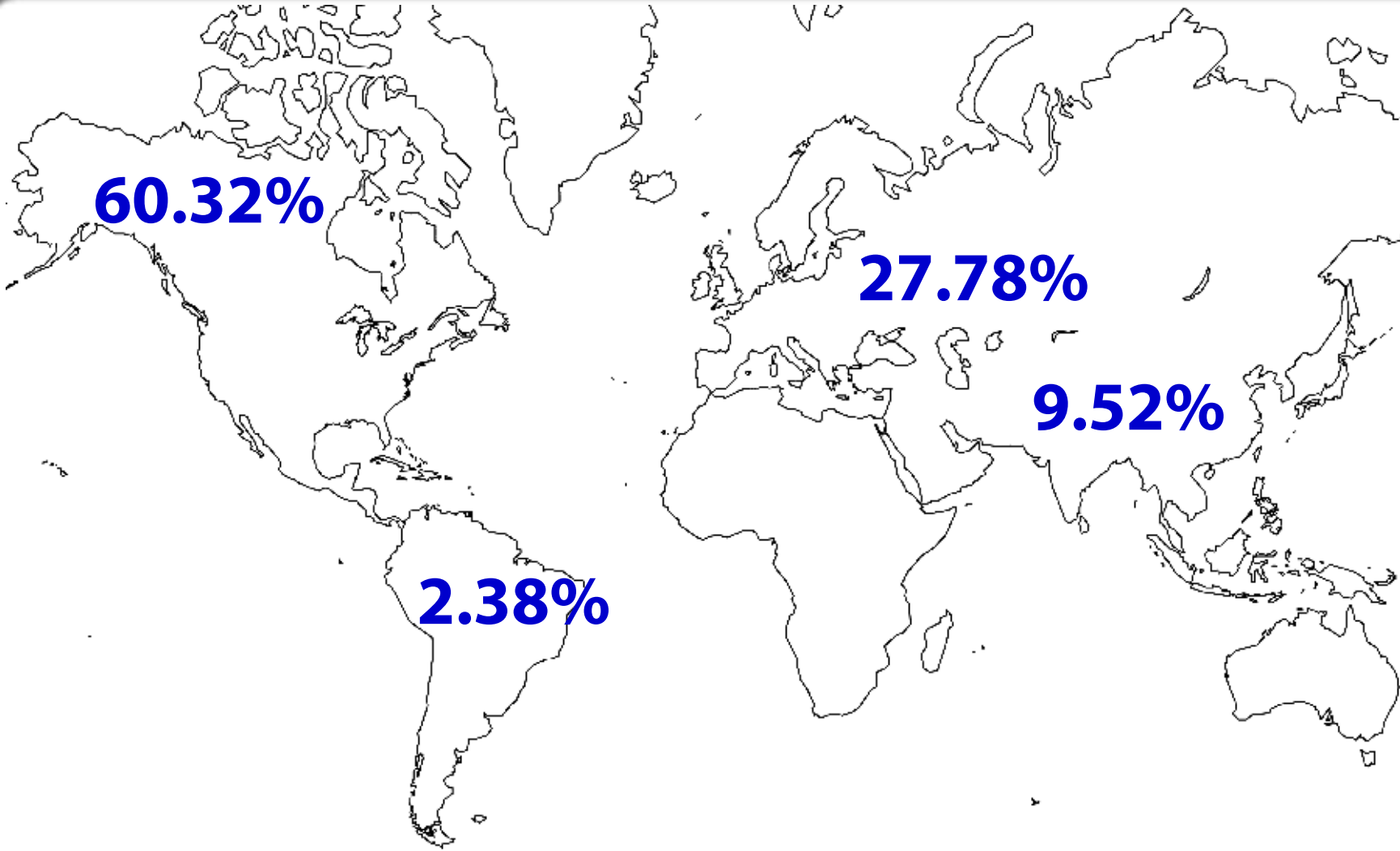
PayPal ACM **Participating Companies** Amgen LISA

HP Synopsys Mastercard

Cisco salesforce.com Sun nvidia

Qualcomm Raytheon eBay Adobe

# Industry Survey Questionnaire Locations

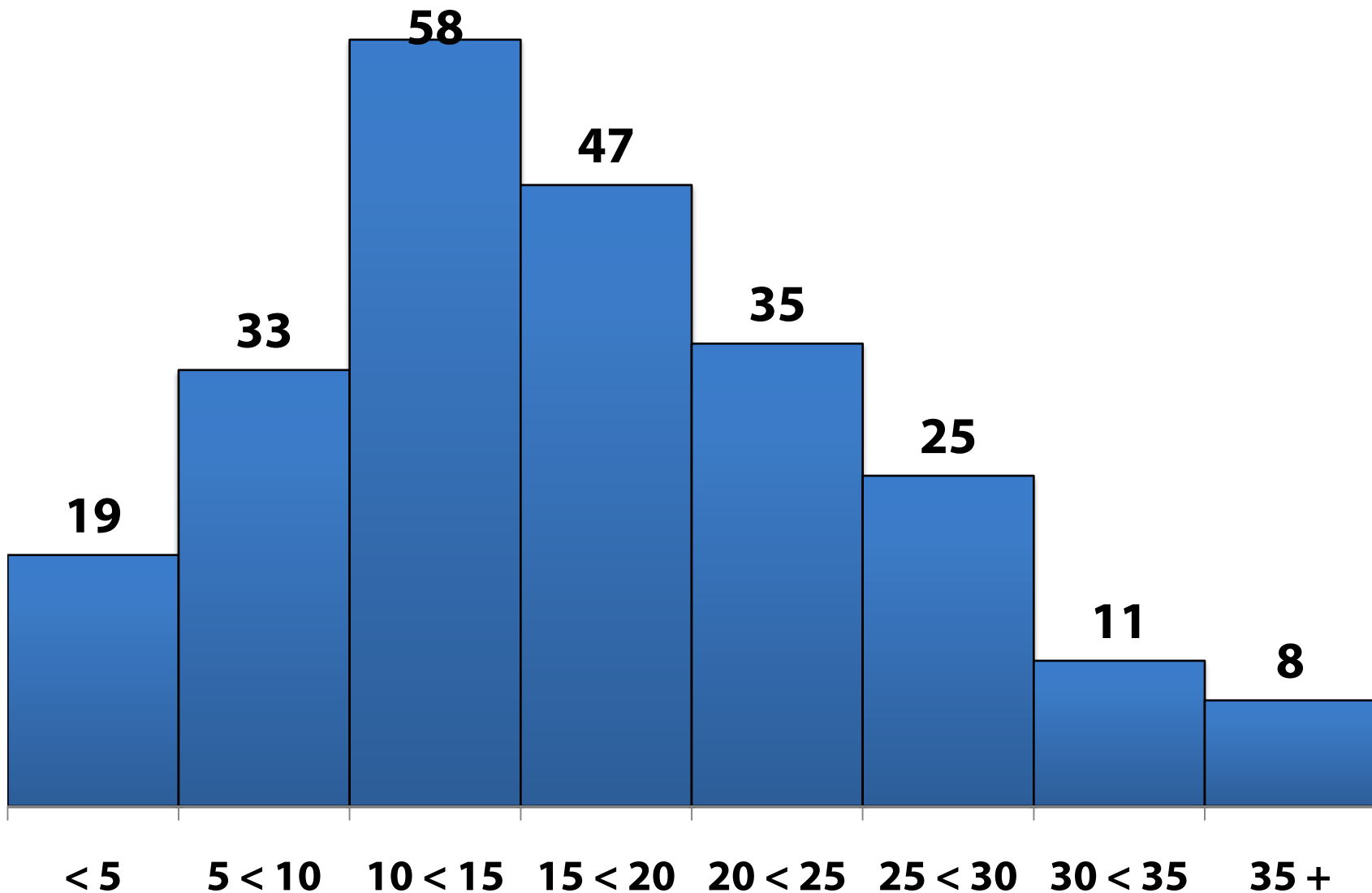


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Image Source: [http://hbw.bristolstories.org/site\\_images/big\\_world\\_map.gif](http://hbw.bristolstories.org/site_images/big_world_map.gif)

# Industry Survey Questionnaire

## Years Working in the Industry



# Industry Survey Questionnaire Titles

**4**

• **Presidents**

**5**

• **Chief Executive Officers**

**10**

• **Chief Technology Officers**

**15**

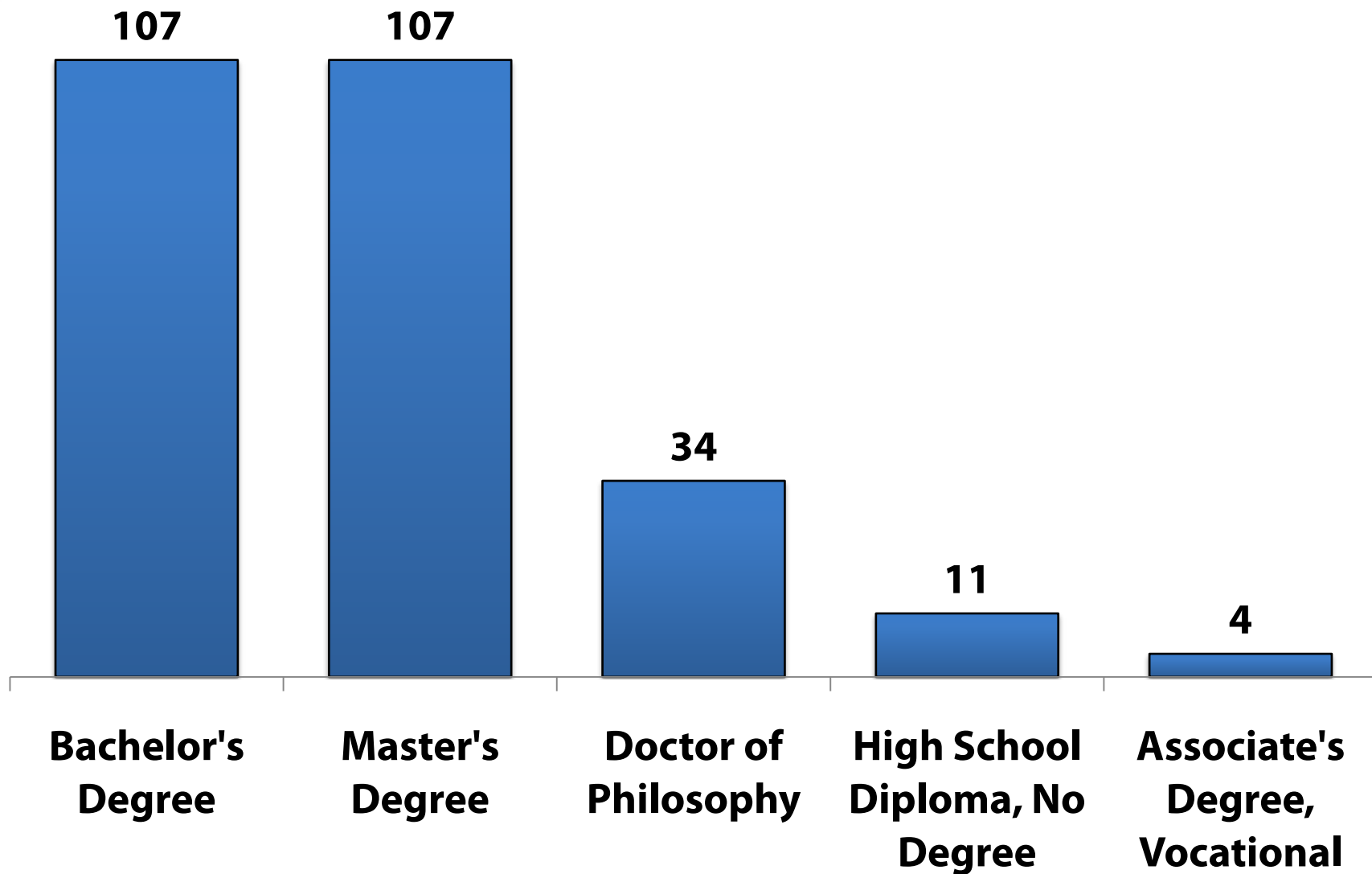
• **Vice Presidents**

**50+**

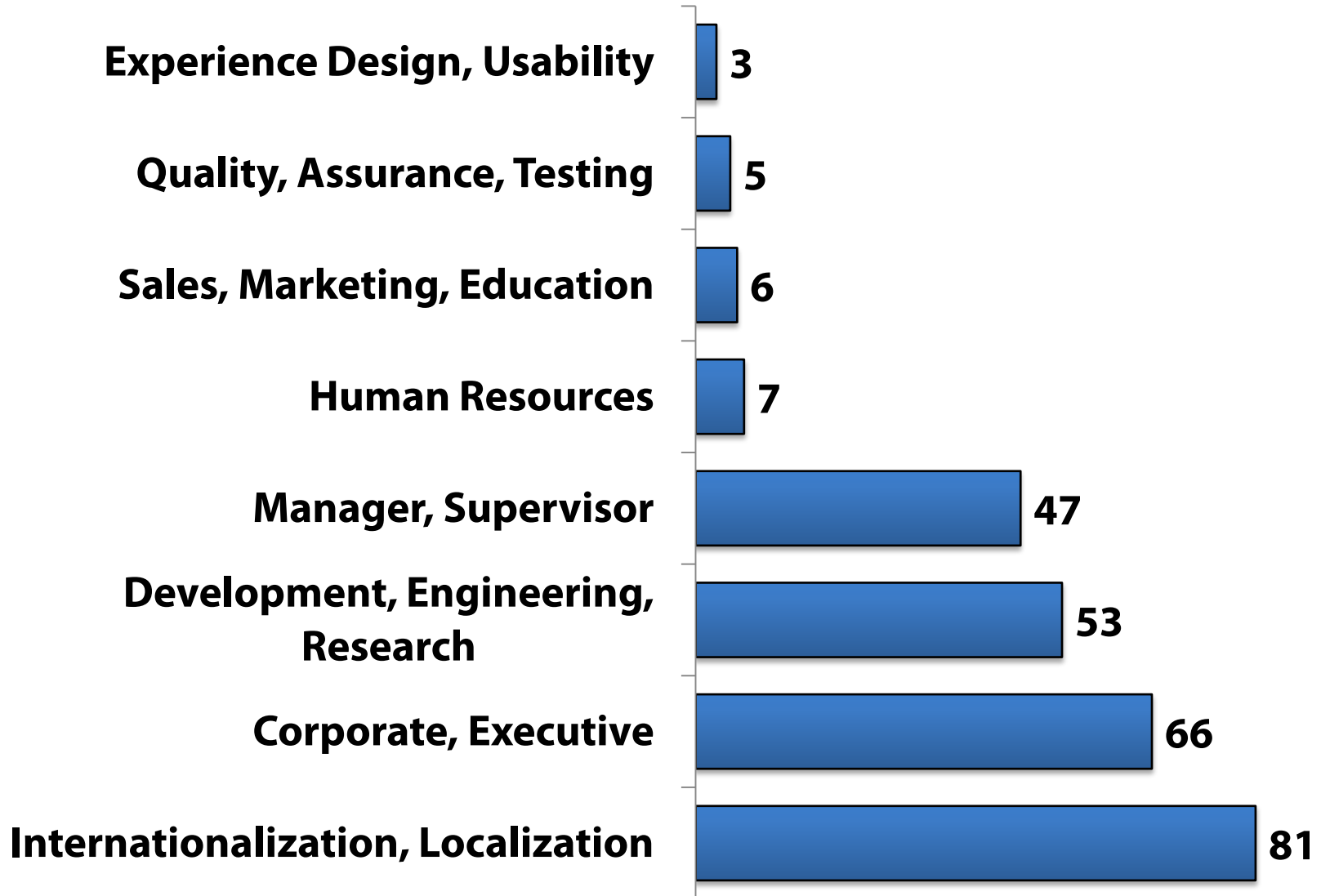
• **Managers, Directors, Principals**

# Industry Survey Questionnaire

## Highest Level of Education



# Industry Survey Questionnaire Group



# Industry Survey Questionnaire

## Calculating the Averages

Abbrev	Average	Abbrev	Average	Abbrev	Average
Technology-Aware	4.4945	Technology-Apply	4.1465	Collation-Apply	3.9186
Dates-Aware	4.4479	Learn	4.1087	Visual	3.8442
Currency-Aware	4.3822	Integrate	4.1051	Standards	3.8309
Direction-Aware	4.3668	Dates-Apply	4.004	Translation-Apply	3.8062
Definitions	4.3248	Currency-Apply	3.996	Colors	3.6836
Apply	4.2924	Laws	3.9783	Noise	3.6460
Collation-Aware	4.2654	Direction-Apply	3.9767	Course	3.2935
Translation-Aware	4.2269	Ethics	3.9538	Abroad	2.5474

# Industry Survey Questionnaire Check for Sample Size

Abbrev	Actual	Abbrev	Actual	Abbrev	Actual
Learn	276	Standards	272	Direction-Apply	258
Apply	277	Colors	275	Collation-Aware	260
Integrate	276	Visual	276	Collation-Apply	258
Course	276	Noise	274	Dates-Aware	259
Abroad	274	Laws	276	Dates-Apply	259
Technology-Aware	273	Translation-Aware	260	Currency-Aware	259
Technology-Apply	273	Translation-Apply	258	Currency-Apply	258
Definitions	274	Direction-Aware	259	Ethics	260



# Industry Survey Questionnaire

## Test for Equal Proportions

Abbrev	Result	Abbrev	Result	Abbrev	Result
Learn	Not Equal	Standards	Not Equal	Direction-Apply	Not Equal
Apply	Not Equal	Colors	Not Equal	Collation-Aware	Not Equal
Integrate	Not Equal	Visual	Not Equal	Collation-Apply	Not Equal
Course	Not Equal	Noise	Not Equal	Dates-Aware	Not Equal
Abroad	Not Equal	Laws	Not Equal	Dates-Apply	Not Equal
Technology-Aware	Not Equal	Translation-Aware	Not Equal	Currency-Aware	Not Equal
Technology-Apply	Not Equal	Translation-Apply	Not Equal	Currency-Apply	Not Equal
Definitions	Not Equal	Direction-Aware	Not Equal	Ethics	Not Equal

# Industry Survey Questionnaire Test for Significant Majority

- **Significant Majority – at least 50%**
- **Testing against two significance values**
  - $\alpha = 0.05$
  - $\alpha = (0.05 / 24) \approx .002$
- **Significance Value** <sup>[60]</sup>
  - Usually denoted  $\alpha$
  - The largest is the largest value that can tolerated
  - Defines the rejection region
  - Chosen depending on the seriousness of a type I error
- **Type I Error** <sup>[60]</sup>
  - When the null hypothesis is rejected when it is true

# Industry Survey Questionnaire

## Test for Significant Majority

- **Significant Majority – at least 50%**
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- **Type I Error** <sup>[60]</sup>
  - When the null hypothesis is rejected when it is true

# Industry Survey Questionnaire

## Test for Significant Majority ( $\alpha = .05$ )

Abbrev	Result	Abbrev	Result	Abbrev	Result
Learn	Overall Agree	Standards	Overall Agree	Direction-Apply	Overall Agree
Apply	Overall Agree	Colors	Overall Agree	Collation-Aware	Overall Agree
Integrate	Overall Agree	Visual	Overall Agree	Collation-Apply	Overall Agree
Course	Neither	Noise	Overall Agree	Dates-Aware	Strongly Agree
Abroad	Neither	Laws	Overall Agree	Dates-Apply	Overall Agree
Technology-Aware	Strongly Agree	Translation-Aware	Overall Agree	Currency-Aware	Overall Agree
Technology-Apply	Overall Agree	Translation-Apply	Overall Agree	Currency-Apply	Overall Agree
Definitions	Overall Agree	Direction-Aware	Overall Agree	Ethics	Overall Agree

# Industry Survey Questionnaire

## Test for Significant Majority ( $\alpha = .05/24$ )

Abbrev	Result	Abbrev	Result	Abbrev	Result
Learn	Overall Agree	Standards	Overall Agree	Direction-Apply	Overall Agree
Apply	Overall Agree	Colors	Overall Agree	Collation-Aware	Overall Agree
Integrate	Overall Agree	Visual	Overall Agree	Collation-Apply	Overall Agree
Course	Neither	Noise	Neither	Dates-Aware	Overall Agree
Abroad	Neither	Laws	Overall Agree	Dates-Apply	Overall Agree
Technology-Aware	Overall Agree	Translation-Aware	Overall Agree	Currency-Aware	Overall Agree
Technology-Apply	Overall Agree	Translation-Apply	Overall Agree	Currency-Apply	Overall Agree
Definitions	Overall Agree	Direction-Aware	Overall Agree	Ethics	Overall Agree

## Conclusion

Resulting Framework

Contributions

Lessons Learned

Future Work

# Conclusion

## Resulting Framework

- **Resulting Framework is found on Table 6**
- **The majority of respondents from the industry **overall agree** that in order for computer science and software engineering graduates to be prepared for industry, universities should teach students software internationalization by integrating the various requirements from Table 6, in order of importance, into current existing courses.**

# Conclusion Contributions

- **Gathered and analyzed requirements**
- **Contacted representatives of the industry**
- **Organized and prioritized requirements**
- **Validated and prioritized requirements**
- **Presented a validated framework**



# Conclusion

## Lessons Learned

- **Universities should pay further attention**
- **Key members of major organizations can be contacted through their member mailing lists**
- **Representatives from the industry have helped guide the research question and thesis**
- **Writing a thesis takes time and motivation**
- **Do not expect to complete a thesis within a timeframe of your choice**

- **Framework implementation**
- **Modifying, adding, or removing requirements**
- **Increase the number of subjects from different companies, programming experiences, or groups of the company**
- **Other possible venues**
- **Evaluate other requirements**

**Thank you!**

Questions? Comments? Concerns?