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

John Huân Vũ
Thesis Defense
March 1, 2010
California Polytechnic State University
San Luis Obispo, California
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 [8]

- **Localization (l11n)**
  - The process of adapting software for a particular geographical region or locale [9]

- **Globalization (g10n)**
  - The process of making all the necessary technical, financial, managerial, personnel, marketing and other enterprise decisions to facilitate international business [9]
Introduction

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 \[10][11]\n
- **Revenues**
  - Top 100 United States software companies
    - Constitutes more than half of the revenues \[5][13]\n  - 2006 Global Fortune 500
    - Yield a revenue of $5.9 trillion, profits of $365 billion \[14]\n
- **Benefits** \[5]\n  - Brings huge savings
  - Increased revenues and profits
  - Shorter product-time to market
Introduction
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]
Introduction

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

Answering the 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\(^5\)
  – Complete, consistent, modifiable, and traceable\(^{37}\)
  – Communication between academia and industry that could serve as a common reference point \(^5\)
State of Education for Internationalization

Requirements Problem
Educational Architectural Models
Set of Requirements from Literature Review
State of Education for Internationalization
Requirements Problem

- **Requirement** [37]
  - 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 [37]

- **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** [1]
  – Most programs employ this model [1]
  – See how topics work with other fields [39]
  – Not discussed in-depth or applied to projects [1]

• Develop an Entire Course

• Study Abroad for Experience
State of Education for Internationalization

Educational Architectural Models

• Integration into Existing Courses

• **Develop an Entire Course** [1]
  – Undoubtedly rare to adopt this model [3][3]
  – Topics are discussed in depth or applied to projects [1][10]
  – Not feasible or cost-effective [3]

• Study Abroad for Experience
State of Education for Internationalization
Educational Architectural Models

- Integration into Existing Courses
- Develop an Entire Course
- **Study Abroad for Experience** [1]
  - Integrate software internationalization first-hand [1][33]
  - Understand the cultural issues, practices, and laws
  - Not feasible or cost-effective [1]
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**
  – 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
• **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
1,000 companies were successfully contacted

361 recorded responses

278 valid responses
Industry Survey Questionnaire
Participating Companies

148 Participating Companies

Siemens  IBM  Rosetta Stone  AMD
Expedia  Google  Opera  Microsoft  LLNL
Trend Micro  ACM  SAP  Yahoo!
Symantec  PayPal  Amgen  LISA
Salesforce.com  HP  Mastercard  Sun  Nvidia
Synopsys  Csco  eBay  Adobe
Qualcomm  Raytheon
Industry Survey Questionnaire
Years Working in the Industry

- < 5: 19
- 5 < 10: 33
- 10 < 15: 58
- 15 < 20: 47
- 20 < 25: 35
- 25 < 30: 25
- 30 < 35: 11
- 35+: 8
Industry Survey Questionnaire

Titles

- Presidents: 4
- Chief Executive Officers: 5
- Chief Technology Officers: 10
- Vice Presidents: 15
- Managers, Directors, Principals: 50+
Industry Survey Questionnaire
Highest Level of Education

- Bachelor's Degree: 107
- Master's Degree: 107
- Doctor of Philosophy: 34
- High School Diploma, No Degree: 11
- Associate's Degree, Vocational: 4
Industry Survey Questionnaire

Group

- Experience Design, Usability: 3
- Quality, Assurance, Testing: 5
- Sales, Marketing, Education: 6
- Human Resources: 7
- Manager, Supervisor: 47
- Development, Engineering, Research: 53
- Corporate, Executive: 66
- Internationalization, Localization: 81
## Industry Survey Questionnaire
### Calculating the Averages

<table>
<thead>
<tr>
<th>Abbrev</th>
<th>Average</th>
<th>Abbrev</th>
<th>Average</th>
<th>Abbrev</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology-Aware</td>
<td>4.4945</td>
<td>Technology-Apply</td>
<td>4.1465</td>
<td>Collation-Apply</td>
<td>3.9186</td>
</tr>
<tr>
<td>Dates-Aware</td>
<td>4.4479</td>
<td>Learn</td>
<td>4.1087</td>
<td>Visual</td>
<td>3.8442</td>
</tr>
<tr>
<td>Currency-Aware</td>
<td>4.3822</td>
<td>Integrate</td>
<td>4.1051</td>
<td>Standards</td>
<td>3.8309</td>
</tr>
<tr>
<td>Direction-Aware</td>
<td>4.3668</td>
<td>Dates-Apply</td>
<td>4.004</td>
<td>Translation-Apply</td>
<td>3.8062</td>
</tr>
<tr>
<td>Definitions</td>
<td>4.3248</td>
<td>Currency-Apply</td>
<td>3.996</td>
<td>Colors</td>
<td>3.6836</td>
</tr>
<tr>
<td>Apply</td>
<td>4.2924</td>
<td>Laws</td>
<td>3.9783</td>
<td>Noise</td>
<td>3.6460</td>
</tr>
<tr>
<td>Collation-Aware</td>
<td>4.2654</td>
<td>Direction-Apply</td>
<td>3.9767</td>
<td>Course</td>
<td>3.2935</td>
</tr>
<tr>
<td>Translation-Aware</td>
<td>4.2269</td>
<td>Ethics</td>
<td>3.9538</td>
<td>Abroad</td>
<td>2.5474</td>
</tr>
</tbody>
</table>
# Industry Survey Questionnaire

Check for Sample Size

<table>
<thead>
<tr>
<th>Abbrev</th>
<th>Actual</th>
<th>Abbrev</th>
<th>Actual</th>
<th>Abbrev</th>
<th>Actual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn</td>
<td>276</td>
<td>Standards</td>
<td>272</td>
<td>Direction-Apply</td>
<td>258</td>
</tr>
<tr>
<td>Apply</td>
<td>277</td>
<td>Colors</td>
<td>275</td>
<td>Collation-Aware</td>
<td>260</td>
</tr>
<tr>
<td>Integrate</td>
<td>276</td>
<td>Visual</td>
<td>276</td>
<td>Collation-Apply</td>
<td>258</td>
</tr>
<tr>
<td>Course</td>
<td>276</td>
<td>Noise</td>
<td>274</td>
<td>Dates-Aware</td>
<td>259</td>
</tr>
<tr>
<td>Abroad</td>
<td>274</td>
<td>Laws</td>
<td>276</td>
<td>Dates-Apply</td>
<td>259</td>
</tr>
<tr>
<td>Technology-Aware</td>
<td>273</td>
<td>Translation-Aware</td>
<td>260</td>
<td>Currency-Aware</td>
<td>259</td>
</tr>
<tr>
<td>Technology-Apply</td>
<td>273</td>
<td>Translation-Apply</td>
<td>258</td>
<td>Currency-Apply</td>
<td>258</td>
</tr>
<tr>
<td>Definitions</td>
<td>274</td>
<td>Direction-Aware</td>
<td>259</td>
<td>Ethics</td>
<td>260</td>
</tr>
<tr>
<td>Abbrev</td>
<td>Result</td>
<td>Abbrev</td>
<td>Result</td>
<td>Abbrev</td>
<td>Result</td>
</tr>
<tr>
<td>--------------</td>
<td>-------------------</td>
<td>------------</td>
<td>-------------------</td>
<td>-----------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>Learn</td>
<td>Not Equal</td>
<td>Standards</td>
<td>Not Equal</td>
<td>Direction-Apply</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Apply</td>
<td>Not Equal</td>
<td>Colors</td>
<td>Not Equal</td>
<td>Collation-Aware</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Integrate</td>
<td>Not Equal</td>
<td>Visual</td>
<td>Not Equal</td>
<td>Collation-Apply</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Course</td>
<td>Not Equal</td>
<td>Noise</td>
<td>Not Equal</td>
<td>Dates-Aware</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Abroad</td>
<td>Not Equal</td>
<td>Laws</td>
<td>Not Equal</td>
<td>Dates-Apply</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Technology-Aware</td>
<td>Not Equal</td>
<td>Translation-Aware</td>
<td>Not Equal</td>
<td>Currency-Aware</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Technology-Apply</td>
<td>Not Equal</td>
<td>Translation-Apply</td>
<td>Not Equal</td>
<td>Currency-Apply</td>
<td>Not Equal</td>
</tr>
<tr>
<td>Definitions</td>
<td>Not Equal</td>
<td>Direction-Aware</td>
<td>Not Equal</td>
<td>Ethics</td>
<td>Not Equal</td>
</tr>
</tbody>
</table>
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** \([60]\)
  – 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** \([60]\)
  – When the null hypothesis is rejected when it is true
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 \[^{[60]}\]
  - Usually denoted $\alpha$
  - The largest value that can tolerated
  - Defines the rejection region
  - Chosen depending on the seriousness of a type I error
- Type I Error \[^{[60]}\]
  - When the null hypothesis is rejected when it is true
<table>
<thead>
<tr>
<th>Abbrev</th>
<th>Result</th>
<th>Abbrev</th>
<th>Result</th>
<th>Abbrev</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learn</td>
<td>Overall Agree</td>
<td>Standards</td>
<td>Overall Agree</td>
<td>Direction-</td>
<td>Overall Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apply</td>
<td></td>
</tr>
<tr>
<td>Apply</td>
<td>Overall Agree</td>
<td>Colors</td>
<td>Overall Agree</td>
<td>Collation-</td>
<td>Overall Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apply</td>
<td></td>
</tr>
<tr>
<td>Integrate</td>
<td>Overall Agree</td>
<td>Visual</td>
<td>Overall Agree</td>
<td>Collation-</td>
<td>Overall Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Apply</td>
<td></td>
</tr>
<tr>
<td>Course</td>
<td>Neither</td>
<td>Noise</td>
<td>Overall Agree</td>
<td>Dates-Aware</td>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Abroad</td>
<td>Neither</td>
<td>Laws</td>
<td>Overall Agree</td>
<td>Dates-Apply</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Technology-</td>
<td>Strongly Agree</td>
<td>Translation-</td>
<td>Overall Agree</td>
<td>Currency-</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Aware</td>
<td></td>
<td>Aware</td>
<td></td>
<td>Aware</td>
<td></td>
</tr>
<tr>
<td>Technology-</td>
<td>Overall Agree</td>
<td>Translation-</td>
<td>Overall Agree</td>
<td>Currency-</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Apply</td>
<td></td>
<td>Apply</td>
<td></td>
<td>Apply</td>
<td></td>
</tr>
<tr>
<td>Definitions</td>
<td>Overall Agree</td>
<td>Direction-</td>
<td>Overall Agree</td>
<td>Ethics</td>
<td>Overall Agree</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aware</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abbrev</td>
<td>Result</td>
<td>Abbrev</td>
<td>Result</td>
<td>Abbrev</td>
<td>Result</td>
</tr>
<tr>
<td>----------</td>
<td>-----------------</td>
<td>-----------</td>
<td>-----------------</td>
<td>---------------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Learn</td>
<td>Overall Agree</td>
<td>Standards</td>
<td>Overall Agree</td>
<td>Direction-Apply</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Apply</td>
<td>Overall Agree</td>
<td>Colors</td>
<td>Overall Agree</td>
<td>Collation-Aware</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Integrate</td>
<td>Overall Agree</td>
<td>Visual</td>
<td>Overall Agree</td>
<td>Collation-Apply</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Course</td>
<td>Neither</td>
<td>Noise</td>
<td>Neither</td>
<td>Dates-Aware</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Abroad</td>
<td>Neither</td>
<td>Laws</td>
<td>Overall Agree</td>
<td>Dates-Apply</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Technology-Aware</td>
<td>Overall Agree</td>
<td>Translation-Aware</td>
<td>Overall Agree</td>
<td>Currency-Aware</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Technology-Apply</td>
<td>Overall Agree</td>
<td>Translation-Apply</td>
<td>Overall Agree</td>
<td>Currency-Apply</td>
<td>Overall Agree</td>
</tr>
<tr>
<td>Definitions</td>
<td>Overall Agree</td>
<td>Direction-Aware</td>
<td>Overall Agree</td>
<td>Ethics</td>
<td>Overall Agree</td>
</tr>
</tbody>
</table>
Conclusion

Resulting Framework
Contribution
Lessons Learned
Future Work
• 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
• 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?