Understanding conceptual transfer in students learning new programming languages

By Ethel Tshukudu, PhD
University of Botswana
tshukudue@ub.ac.bw
MOTIVATION ANDAIMS

- Difficulties students face during transition
- PhD research
  - Conceptual transfer in students learning new programming languages
- Aim
  - Explore and Investigate how transfer occurs in relative novice programmers during **code comprehension**
    - Drew heavily from natural language theories
      - Psycholinguistic model-Lexical representation and development in a second language- Jiang Nan
      - Cross-linguistic similarities-Ringbom
RESEARCH DESIGN

*Semantic transfer based on syntax similarities plays a role*
Phase 1-Exploring transfer (Qualitative study)
Phase 2-Model of PL transfer
Phase 3-Model Validation (Quantitative - 4 studies)

*Transfer interventions can lead to improved conceptual transfer and understanding*
Phase 4-Teachers’ experiences and transfer interventions (Qualitative)
Phase 5-Transfer pedagogy (Qualitative and quantitative - 2 studies)
CONTRIBUTIONS

Model of PL transfer:

- validated in one context (Python-Java).
- Similar syntax + similar semantics = positive transfer
- Similar syntax + different semantics = negative transfer
- Different syntax + similar semantics = minimal or no transfer
A construct with
- similar syntax
- similar underlying semantics in PL1 and PL2.
- For example, a while loop in Python and Java.
EXAMPLE FALSE CARRYOVER CONCEPT (FCC)

- A construct with
  - similar syntax
  - Different semantics in PL1 and PL2.
- For example, equality of arrays in Python 3 and Java

<table>
<thead>
<tr>
<th>FCC</th>
<th>Equality of arrays</th>
<th>PL1</th>
<th>PL2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>e = [1, 2, 3]</td>
<td>int[]{ }e = {1, 2, 3};</td>
<td>System.out.println(e==f)</td>
</tr>
<tr>
<td></td>
<td>f = [1, 2, 3]</td>
<td>int[]{ }f = {1, 2, 3};</td>
<td></td>
</tr>
<tr>
<td></td>
<td>print(e==f)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
EXAMPLE: ABSTRACT TRUE CARRYOVER CONCEPT (ATCC)

- A construct with
  - Different syntax
  - Similar underlying semantics in PL1 and PL2.
- Examples are constructs, whose implementation details are hidden such as data abstraction (objects) in Java which at a low level can represent data structures like Python dictionaries but has structured data and behavior.
Second year students
• European universities
• Python-Java

Similarities between programming languages play a significant role in semantic and conceptual transfer between programming languages.

Figure 6.12: Mean scores of individual concepts tested in Study 2c when participants in week 3 of learning Java (PL2): N=70
CONTRIBUTIONS

- Pedagogy of transfer:
  - This thesis also shows how the MPLT was used to shape the design of a transfer pedagogy in the classroom.
- Teacher preparation: Data showing teachers are not aware of the issues hence professional development may be needed.
DEEP LEARNING FROM THE THESIS

- **Multiple Programming Languages in the Curriculum**
  - Recommended by ACM and IEE guidelines for undergrad CS
  - K-12 also

- **Relative Novices’ Fragile Knowledge (inert, partial and misplaced by Perkins et al)**
  - Educators focus on problem solving
  - Educators overestimate knowledge of PL1
  - Second language educators assumes a lot of knowledge that is not in place

- **Deepening Conceptual Understanding through Second Language Learning**
  - Finding gaps in knowledge
  - Opportunity to teach hidden concepts e.g. scoping, aliasing etc
  - Allowing students to fail and correct
  - Comparisons
    - Correcting and connecting
NEXT STEPS AND QUESTIONS

- **Questions:**
  - I often get asked:
    - Which is the best first PL to start with?
    - Transfer in other language contexts?

- **Question to you:**
  - Who is my research relevant to?
    - Pure relative novices not CS majors?
    - CS majors (CS0 and CS1)?
    - Anyone?

- **Next Steps:**
  - Further validation of the model in new contexts
  - Further validation of the pedagogy in new contexts
  - Exploring more deepening conceptual understanding
MAIN THESIS PUBLICATIONS


- Ethel Tshukudu, Quintin Cutts, Mary Ellen Foster. 2021. Evaluating a Pedagogy for Improving Conceptual Transfer and Understanding in a Second Programming Language Learning Context. KoliCalling ’21:
THANK YOU

By Ethel Tshukudu, PhD
University of Botswana
tshukudue@ub.ac.bw
Website: https://www.csedbotswana.org/