It Will Never Work in Theory
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Understanding conceptual transfer in students learning new programming languages

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MOTIVATION AND AIMS

- 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
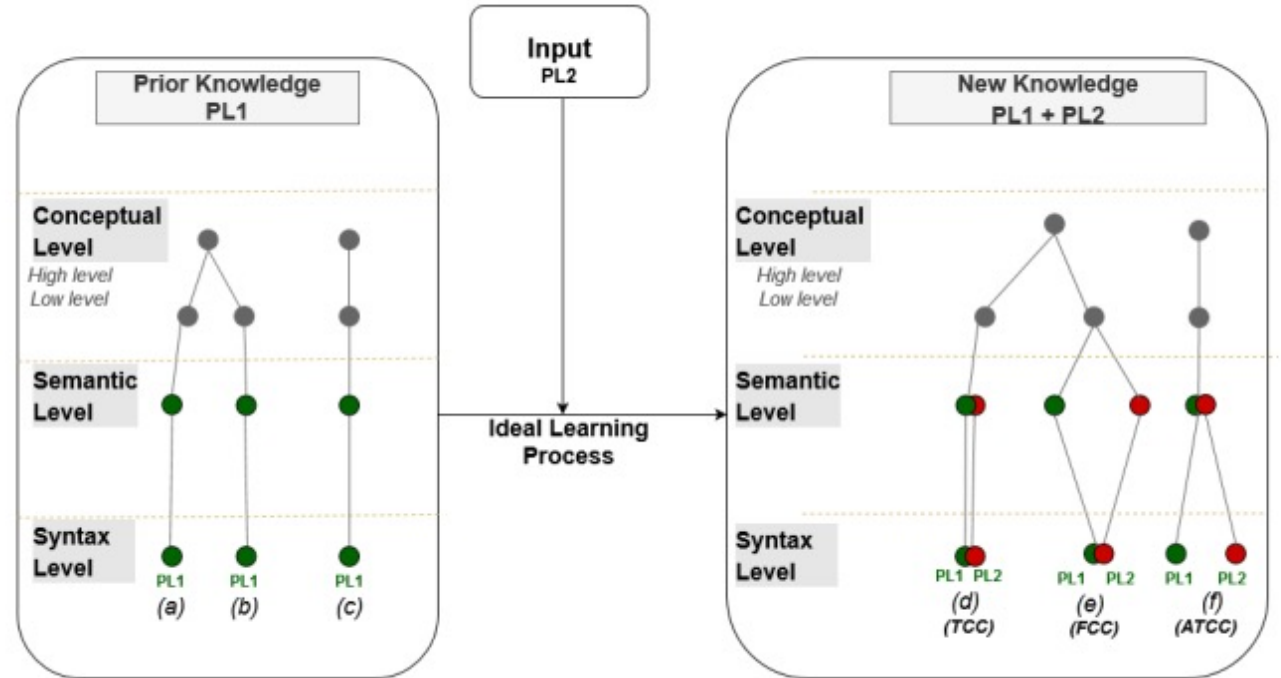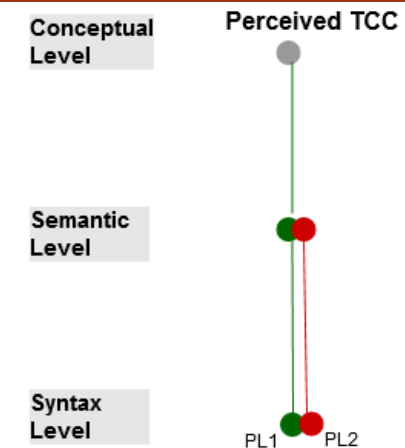
EXAMPLE: TRUE CARRYOVER CONCEPT (TCC)

- A construct with
  - similar syntax
  - similar underlying semantics in PL1 and PL2.
- For example, a while loop in Python and Java.

Construct Category	Construct	Python	Java

TCC	While Loop	`sum = 0`
		`i = 0`
		`while i < 3:`
		`        sum=sum+i`
		`        i += 1`
			`int sum = 0;`
			`int i = 0;`
			`while (i < 3){`
			`        sum=sum+i;`
			`        i += 1;}`

Potential relationship between languages

TCC

Effects of semantic transfer

Perceived TCC
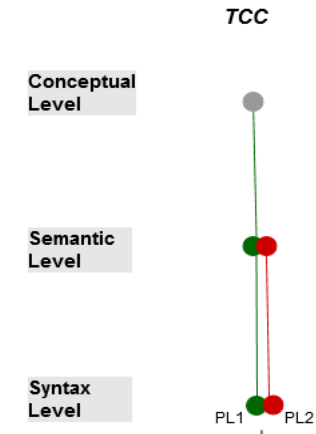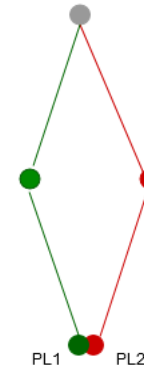
EXAMPLE FALSE CARRYOVER CONCEPT (FCC)

Potential relationship between languages

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

FCC

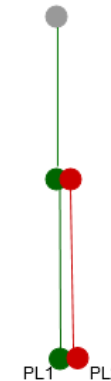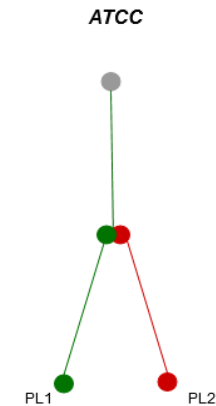| FCC	Equality of arrays	e = [1, 2, 3] f = [1, 2, 3] print(e==f)	int[] e = {1, 2, 3}; int[] f = {1, 2, 3}; System.out.println(e==f)

Effects of semantic transfer

Perceived TCC

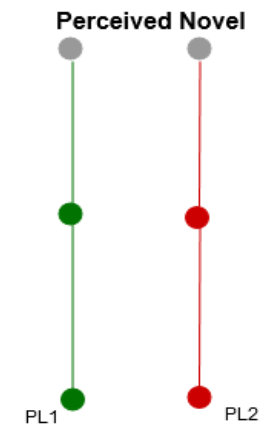# EXAMPLE: ABSTRACT TRUE CARRYOVER CONCEPT (ATCC)

- 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
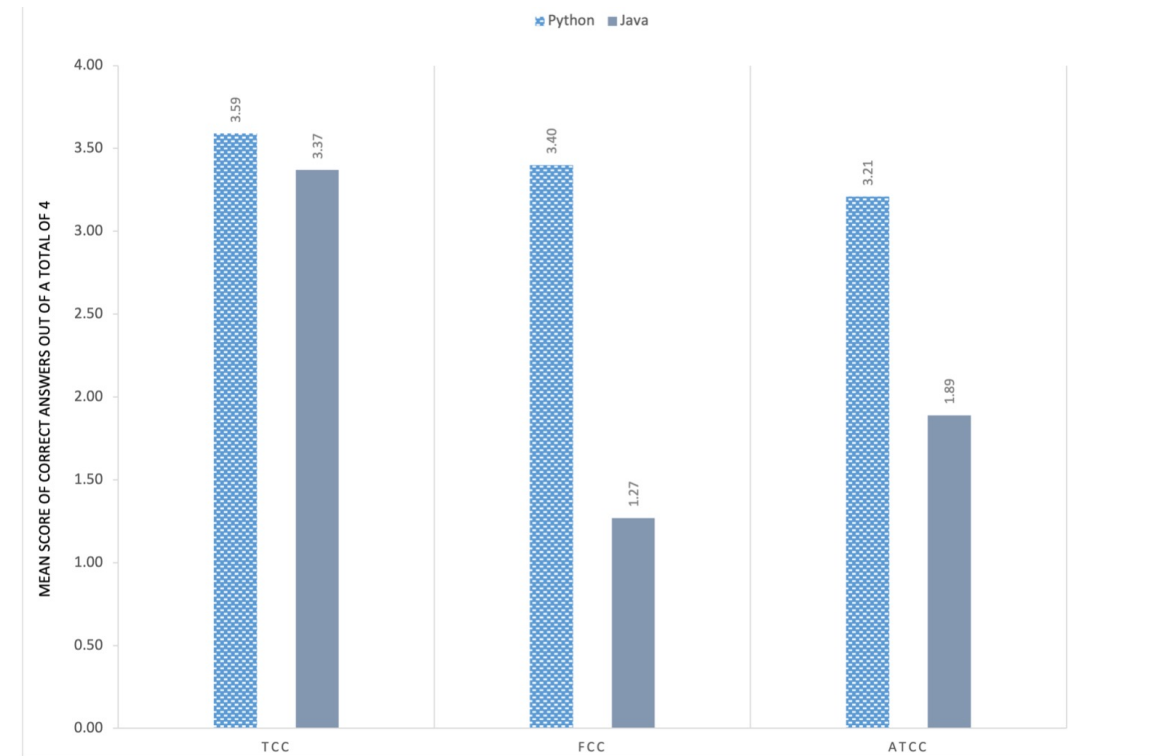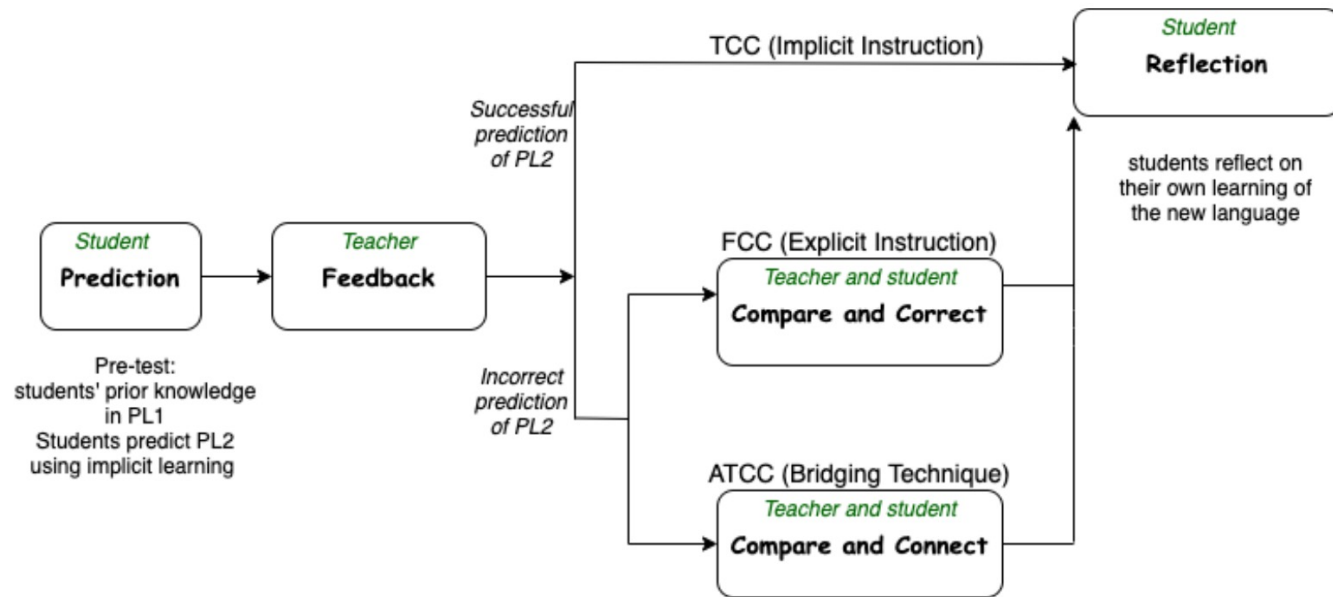
| ATCC | Object Aliasing | `n1={'name':'Joseph', 'age': 51}`
`n2={'name':'Vic', 'age': 35}`
`n1=n2`
`n2['age']=n2['age']+1`
`print(n1['age'])` | ```public class Robot {
    String name;
    int age;
    public Robot(String n, int w){
        this.name=n;
        this.age=w; }
    public static void main(String[]args){
        Robot n1=new Robot("Joseph", 51);
        Robot n2=new Robot("Vic", 35);
        n1=n2;
        n2.agga();
        System.out.println(n1.age);}
    public int agga(){
        age=age+1;
        return age;}}
``` |
|------|------|------|------|

Potential relationship between languages

ATCC
PL1   PL2

Effects of semantic transfer

Perceived Novel
PL1   PL2

VALIDATION OF THE MODEL

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 class- room.
  - 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 and Quintin Cutts. 2020. Semantic Transfer in Pro- gramming Languages: Exploratory Study of Relative Novices. In Proceedings of the 2020 ACM Conference on Innovation and Technology in Computer Science Education. 307–313. [29].

- Ethel Tshukudu and Quintin Cutts. 2020. Understanding Conceptual Transfer for Students Learning New Programming Languages. In Proceedings of the 2020 ACM Conference on International Computing Education Research. 227–237. [30]

- Ethel Tshukudu and Quintin Cutts. [n. d.]. Understanding conceptual transfer in second and subsequent programming languages. In Cambridge Computing Education Research Symposium. 18. [31]

- Ethel Tshukudu and Siri Annethe Moe Jensen. 2020. The Role of Explicit Instruction on Students Learning their Second Programming Language. UKICER '20: United Kingdom Ireland Computing Education Research conference. 10-16 [33]

- Ethel Tshukudu, Quintin Cutts, Olivier Goletti, Alaaeddin Swidan, and Fe- lienne Hermans. 2021. Teachers' Views and Experiences on Teaching Second and Subse- quent Programming Languages . In Proceedings of the 17th ACM Conference on Interna- tional Computing Education Research (ICER 2021), Au- gust 16-19, 2021, Virtual Event, USA. ACM, New York, NY, USA, 12 pages. https://doi.org/10.1145/3446871.3469752

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

THANK YOU

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