Student Learning & Motivation in Active Learning Environments in Undergraduate Computer Science Classrooms

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Motivation

- **Active learning** is an emerging student-centered paradigm in which students not only passively listen, but also read, write, **discuss, be engaged in solving problems and also actively think and react** during the learning process.
- Active Learning is **comparatively new** to the undergraduate CS classrooms.
- Preliminary findings on active learning pedagogies have raised hopes for a **more holistic, student-centered, and inclusive Computer Science education** at the undergraduate level.

Background

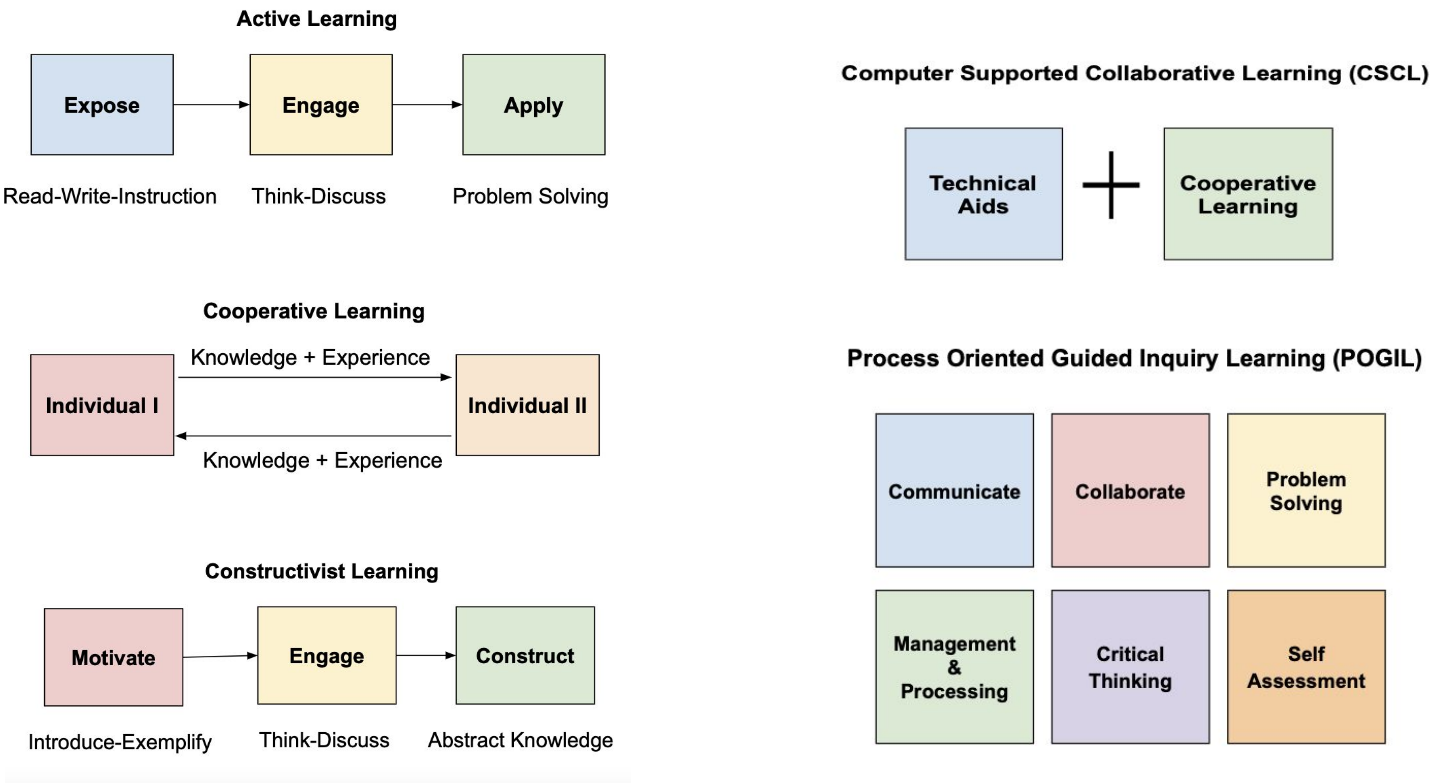

Figure 1: Cognitive Learning Theories in STEM classrooms

Objectives

The objective of this study is to understand why and how pedagogical approaches to Computer Science education enhance student learning and motivation and how these parameters are measured in undergraduate Computer Science classrooms.

- **Research Question 1**: What learning pedagogies support constructivist active learning environments in CS classrooms?
- **Research Question 2**: How is student learning and motivation in active team-based learning environments measured?
- **Research Question 3**: How does a CSCL model for POGIL support student learning and motivation?

Methods

- For our first research question, we analyzed relevant literature to **identify practical implementations of learning theories** such as constructivism, team based cooperation and inquiry in undergraduate Computer Science classrooms.
- For our second research question, we **identified variables and parameters that the authors employed** to assess student learning and student motivation in the respective studies.
- For our third research question, we developed an **implementation of a novel framework that integrates state of the art Process Oriented Guided Inquiry Learning pedagogy with Computer Supported Collaborative Learning paradigm** with an emphasis on improving student learning and motivation.

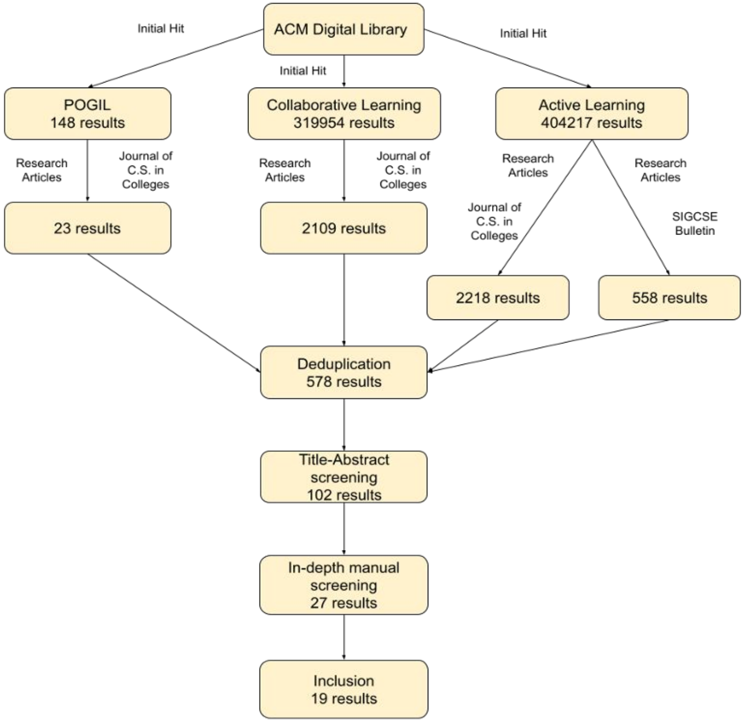

Figure 2: Literature review selection and inclusion process

Results & Discussion

Active Learning Pedagogy/Variant	Frequency
POGIL	6/19
Collaborative/Cooperative Learning	7/19
Pair Programming	1/19
Peer Instruction	4/19
Peer Led Team Learning (PLTL)	1/19
Problem Based Learning	1/19
Flipped Classroom	1/19

- In most studies, the constructivist component arises from the fact that **most study designs were offshoots of the cooperative/collaborative learning** models.
- It appears that highly controlled, coordinated, **well-organized and guided collaborative learning environments are more explicitly constructivist.**
- POGIL emerges to be a strongly constructivist learning paradigm. **POGIL models and critical thinking prompts are inherently constructivist in nature.**

Results & Discussion

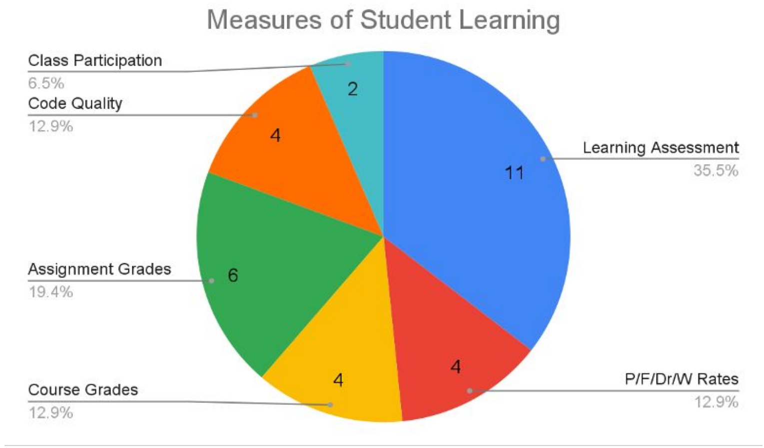

Figure 3: Data Coding on the basis of measures of learning

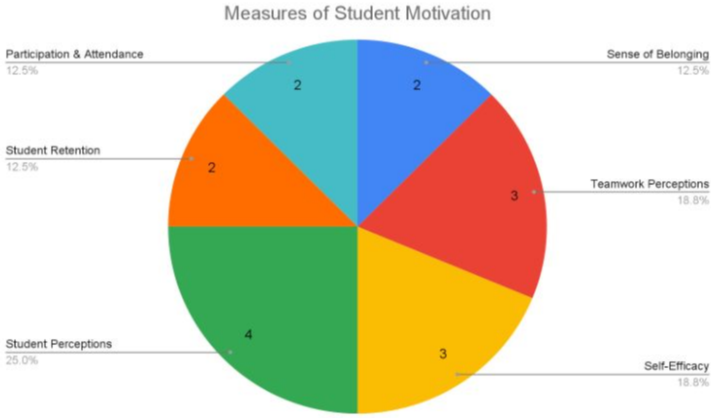

Figure 4: Data Coding on the basis of measures of motivation

- Analysis indicates that **measurement of student learning is much more prevalent across the studies** in our collection in comparison to student motivation.
- There seems to be a **tendency to employ some kind of course-related numeric parameter to quantify student learning** such as scores on learning assessments, grades on assignments, final course grades/cutoffs and pass/fail/drop/withdraw rates.
- Unlike the metrics of student learning where course-based numeric parameters were employed as metrics, **metrics of student motivation seems to be more subjective even in the presence of objective metrics** such as student retention and attendance.

Results & Discussion

- Our model is a **hybrid of POGIL and CSCL** with an introduction of a **guided coding paradigm**.
- Our model adopts **POGIL's structured collaborative learning and Explore-Invent-Apply (EIA) cycles** and exploits **CSCL's collaborative abilities to supplement the EIA cycles**.
- We extend POGIL's vision of guided inquiry based learning to coding problems in Computer Science classrooms by **dividing coding into several phases** wherein each phase is accompanied by an instructional question or comment that **invites students to think about the relevance of that phase to the overall problem**.

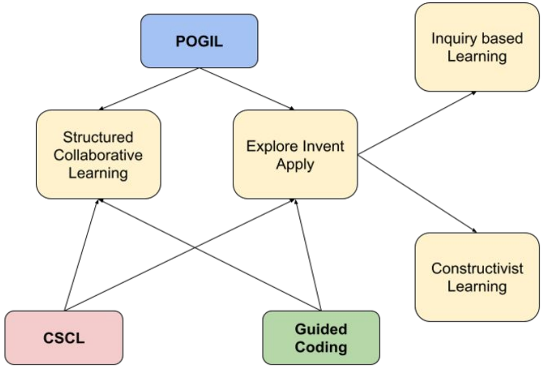

Figure 5: Pedagogical foundations of POGIL-CSCL implementation

```
put(val){
        Step 1: Calculate the index.
        1.
        Step 2: Create a node that stores the value to be hashed.
        2.
        Step 3: Think about the case where there is no collision during insertion and handle it.
        3.
        Step 4: Think about the case where there is a collision during insertion and handle it.
        4.
        We're done! YAY!
}
```

Figure 6: An implementation of our proposed guided coding paradigm

Implications for Future Research

- Our claims in this study are established on the basis of literature review and not statistical analysis. Therefore, our work could potentially be **extended to conduct analytical statistical analysis** on our claims to establish their validity.
- Our analysis reveals that **very little is known about POGIL intervention in upper level undergraduate Computer Science classrooms**. Future research should, therefore, study the implications of POGIL in such classrooms.
- While our proposed model is justified theoretically, it needs to be **validated in much more general context through an application and analysis on a statistically significant sample size**. Therefore, we invite future researchers to implement our proposed model in undergraduate CS classrooms of statistically significant sample sizes and report their observations and subsequent analysis so that our model may be refined.

Thank you!

For further questions, please reach out to me at mtalwar@umass.edu