An Introduction to Applied Quantum Computing

Angel Bajracharya
Adelphi University

Agenda

- Research Question
- What is Quantum Computing?
- Quantum Algorithms
- Methodology
- Class Environment
- Research Findings
- Conclusion

Research Question

What types of quantum computing problems can undergraduate computer science students solve?

What is Quantum Computing?

Classical computing: stores data in the form of bits that can be represented by 1 or 0 ie. true or false.

Quantum computing: stores data in the form of quantum bits, aka ***qubits***, and harnesses principles of quantum mechanics (such as superposition and entanglement) to cause exponential speedups

Quantum Properties

- **<u>Superposition</u>**: allows the qubit to be in a state of 1 and 0 simultaneously
- **<u>Entanglement</u>**: multiple qubits being linked to each other
- **<u>Quantum Parallelism</u>**: exploring multiple possible states simultaneously

Quantum Algorithms

Deutsch-Josza Algorithm

Evaluates whether a function is constant or balanced given an n-bit string

Grover's Algorithm

Sorts an unordered database

Shor's Algorithm

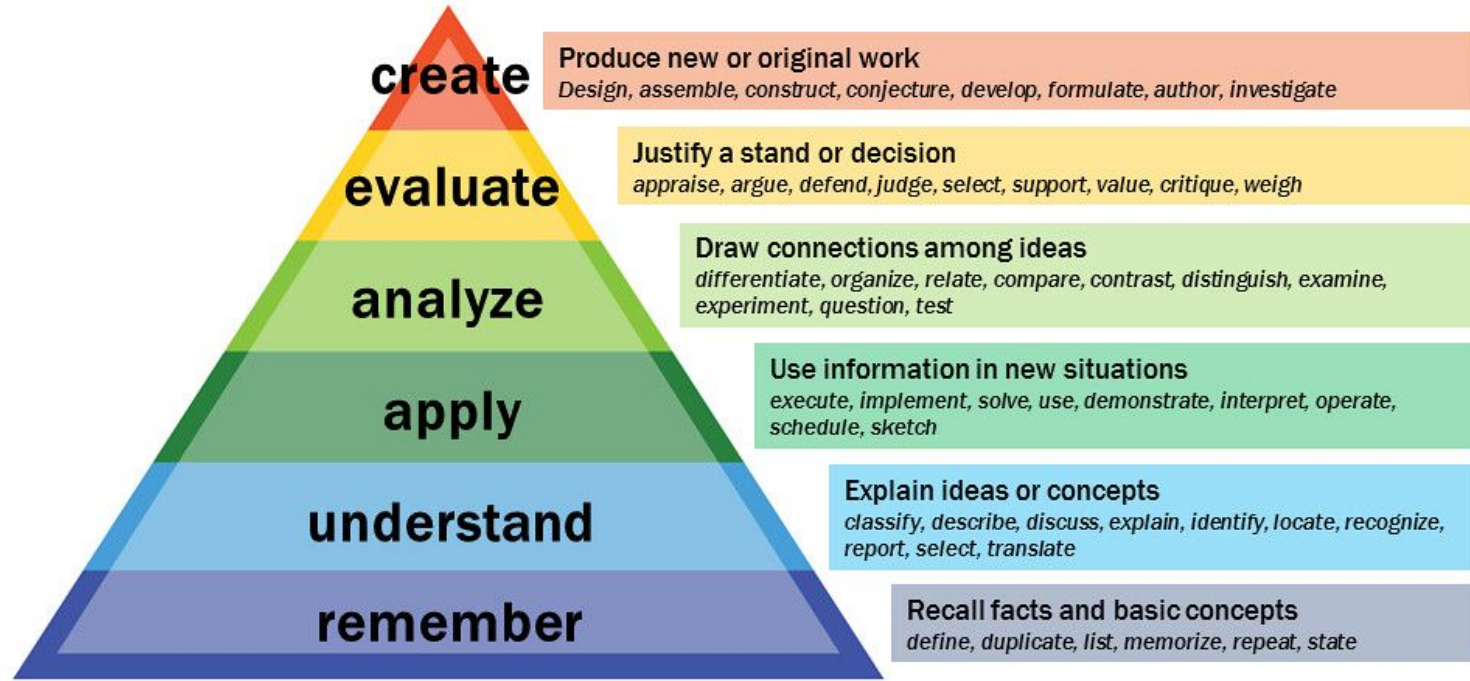Factorizes large composite numbers

Process

Literature Review

Design lecture plan + lab

Introduce it to CS class

Bloom's Taxonomy

create
Produce new or original work
Design, assemble, construct, conjecture, develop, formulate, author, investigate

evaluate
Justify a stand or decision
appraise, argue, defend, judge, select, support, value, critique, weigh

analyze
Draw connections among ideas
differentiate, organize, relate, compare, contrast, distinguish, examine, experiment, question, test

apply
Use information in new situations
execute, implement, solve, use, demonstrate, interpret, operate, schedule, sketch

understand
Explain ideas or concepts
classify, describe, discuss, explain, identify, locate, recognize, report, select, translate

remember
Recall facts and basic concepts
define, duplicate, list, memorize, repeat, state

Student Engagement

- Total students: 26
- Moodle Submissions: 14
- Code-only Submissions: 5
- Lab Packet Submissions: 9
- Survey Submissions: 3

Student Performance

Quantum Hello World

- Hadamard gate understanding: 100%
- Understanding classical bits: 78%
- Interpretation of histogram: 78%

Deutsch-Jozsa Algorithm

- Deutsch-Jozsa algorithm explanation: 45%
- Pseudocode translation: 56%
- Circuit diagram interpretation: 89%

Conclusion

Question: What types of quantum computing problems can undergraduate computer science students solve?

Hypothesis: Deutsch-Jozsa, Grover's, Shor's

Answer: Implementing either of the three introductory algorithms was not feasible. However, students did show high levels of engagement and understanding of the fundamental principles.
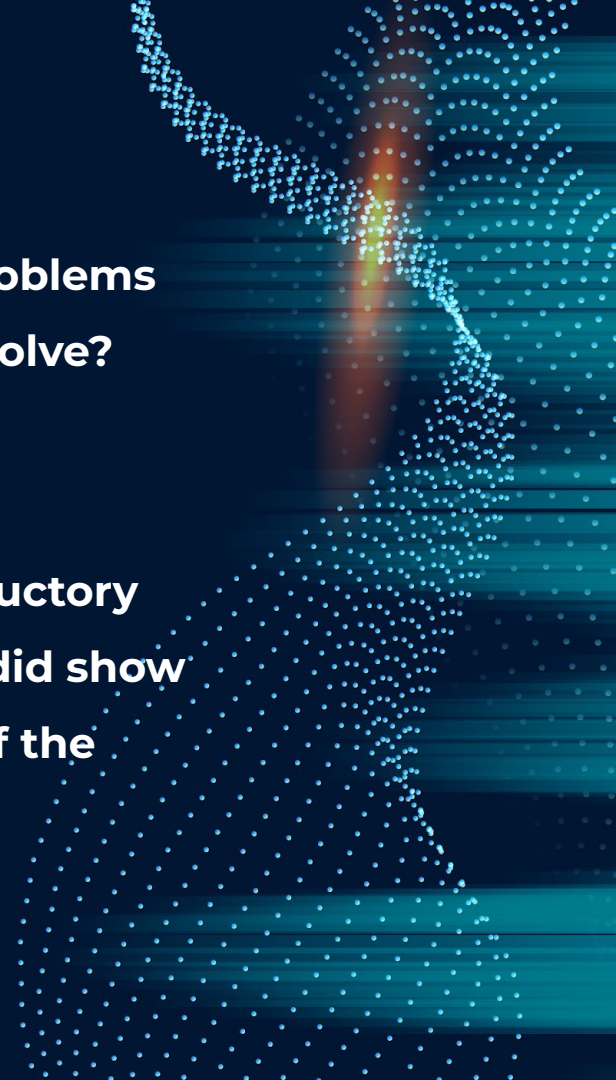
Next StepsFuture Work

- Larger sample size
- Develop a curriculum based on this lecture-lab session
- Graded assignments