Welcome! We are a team of Software Engineering researchers at University of California, Irvine, investigating programming practices in Quantum Programming. Your input will help us understand practitioners' perceptions on a set of previously identified bad programming practices in quantum computing. This survey consists of 15 questions (6 background questions and 9 quantum-related questions) that should take approximately 15 minutes to complete. The results of this survey will be used in a scientific publication.

By clicking the button below, you acknowledge that your participation in the study is voluntary, you are at least 18 years of age, and that you are aware that you may choose to terminate your participation in the study at any time and for any reason. Please contact Iftekhar Ahmed (iftekha@uci.edu) if you have any questions or concerns.

Q1 – Would you like to continue to finish this survey?

[ ] I consent
[ ] I do not consent

Q2 – How long have you been programming?

[ ] Never
[ ] Less than 1 year
[ ] 1 year or more but less than 2 years
[ ] 2 years or more but less than 5 years
[ ] 5 years or more but less than 10 years
[ ] 10 years or more but less than 15 years
[ ] 15 years or more but less than 20 years
[ ] Over 20 years

Q3 – Please select from the following list the classical programming languages that you are comfortable programming with:

[ ] Python
[ ] Java
[ ] C/C++
[ ] C#
[ ] Haskell
[ ] Other: _____

Q4 – What is your level of knowledge in quantum physics?

[ ] 0 (no knowledge)
[ ] 1 (novice)
[ ] 2
[ ] 3
[ ] 4
[ ] 5 (expert)

Q5 – How many years have you been coding using Quantum Programming Languages?

[ ] Never
[ ] Less than 1 year
[ ] 1 year or more but less than 2 years
[ ] 2 years or more but less than 5 years
[ ] 5 years or more but less than 10 years
[ ] 10 years or more but less than 15 years
[ ] 15 years or more but less than 20 years
[ ] Over 20 years

Q6 – Please select from the following list the quantum programming languages / frameworks the ones that you have been using or a familiar with:

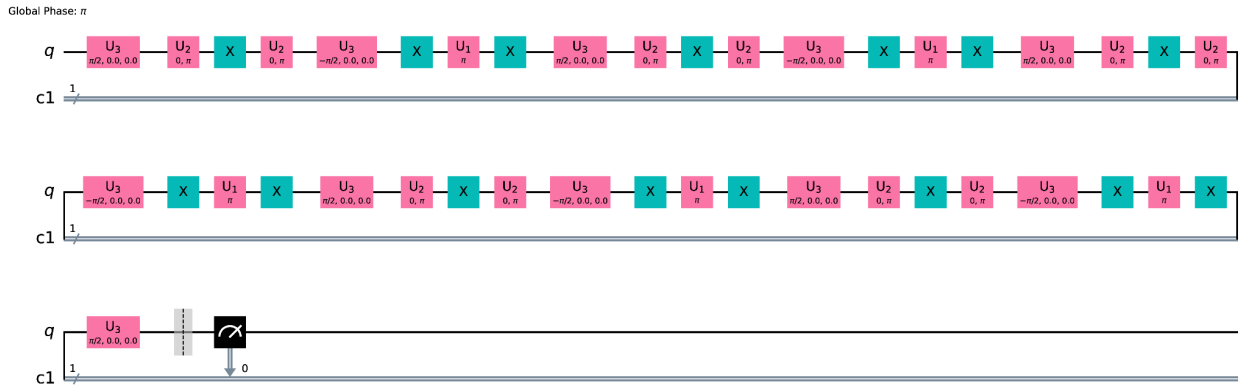
[ ] Cirq
[ ] OpenQASM
[ ] ProjectQ
[ ] Qiskit
[ ] qGCL
[ ] QHaskell
[ ] Q#
[ ] Silq
[ ] Strawberry Fields
[ ] Other: _____

Q7 – Usage of Customized Gates (CG): Although quantum frameworks (e.g., Qiskit) allow one to define customized gates, it is recommended to use the ones built-in those frameworks. Customized gates, when decomposable into built-in operators, do often require a higher number of operators in comparison to equivalent solutions made exclusively of built-in operators. Furthermore, the built-in operators are already optimized thus reducing the probability of circuit errors. Therefore, the usage of customized gates should be used only when it is absolutely necessary.

According to this description, do you agree the *Usage of Customized Gates (CG)* is a bad practice?

[ ] Yes
[ ] No
[ ] I do not know

Q8 – Repeated set of Operations on Circuit (ROC): Due to current technological and physical limitations, the number of operations one can pass to a quantum computer is limited. Thus, the circuit implementing the entire algorithm/program should be prepared in a way that the number of sequential repeated sets of operations to be performed should be the least possible.



According to you, is the quantum circuit above affected by the *Repeated set of Operations on Circuit (ROC)* bad practice? Note: the draw of the circuit above is splitted in three to ease one to read it without having to do any horizontal scroll.

[ ] Yes
[ ] No
[ ] I do not know

Q9 – Non-parameterized Circuit (NC): Real quantum devices work in a shared environment where each request (e.g., the execution of a quantum circuit) is queued. To reduce payloads of communication and delays of running the quantum circuit several times due to queuing, one should try to idealize the entire circuit with focus on reducing the number of communications with the real quantum devices by using, for example, parameterized circuits. In Qiskit, for example, this can be achieved by using the bind_parameters method in a QuantumCircuit object.

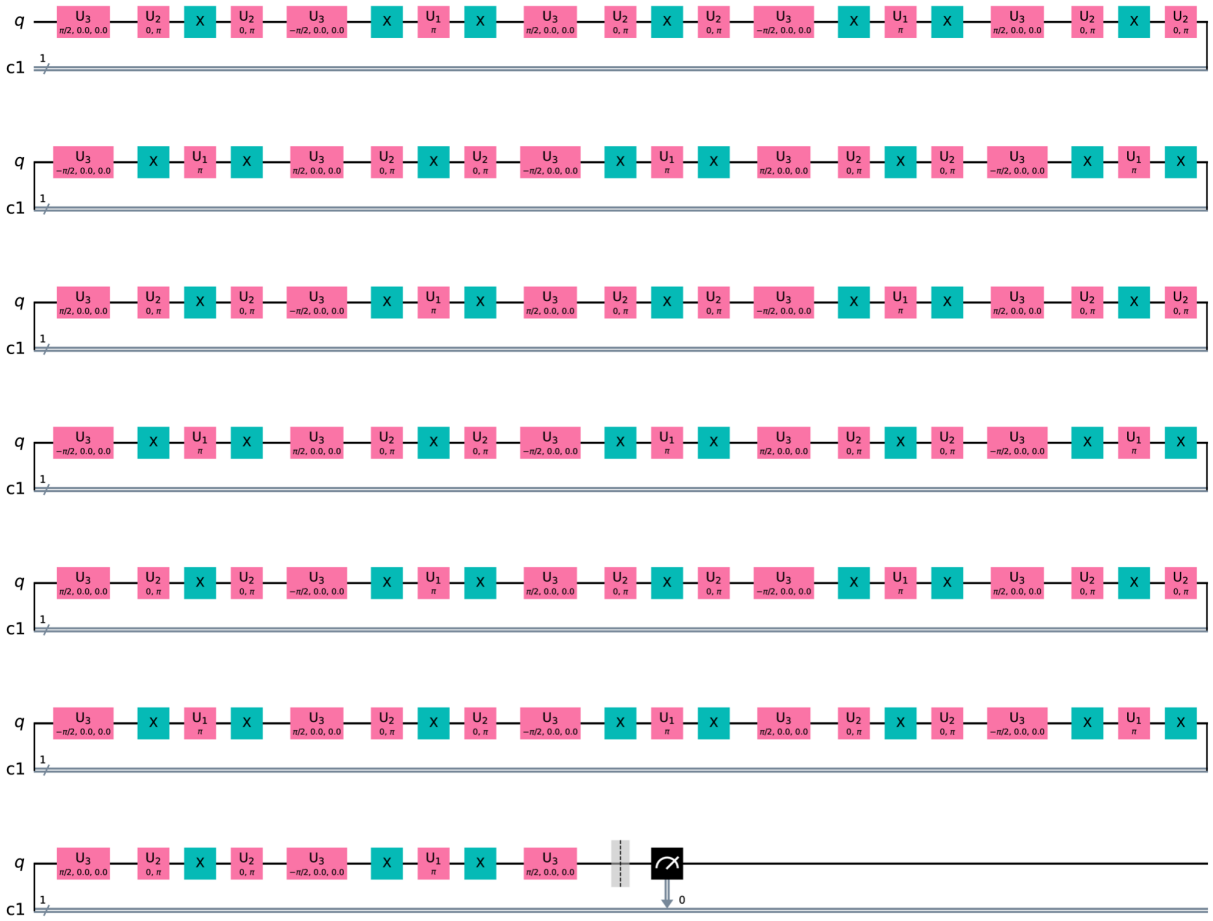
```
## Code extracted from
##
https://github.com/Qiskit/qiskit-terra/blob/0.21.0/qiskit/algorithms/phase_estimators/ipe.py#L
112

def _estimate_phase_iteratively(self, unitary, state_preparation):
    """
    Main loop of iterative phase estimation.
    """
    omega_coef = 0
    # k runs from the number of iterations back to 1
    for k in range(self._num_iterations, 0, -1):
        omega_coef /= 2
        if self._quantum_instance.is_statevector:
            qc = self.construct_circuit(
                unitary, state_preparation, k, -2 * numpy.pi * omega_coef, measurement=False
            )
            result = self._quantum_instance.execute(qc)
            complete_state_vec = result.get_statevector(qc)
            ancilla_density_mat = qiskit.quantum_info.partial_trace(
```

```
                complete_state_vec, range(unitary.num_qubits)
            )
            ancilla_density_mat_diag = numpy.diag(ancilla_density_mat)
            max_amplitude = max(
                ancilla_density_mat_diag.min(), ancilla_density_mat_diag.max(), key=abs
            )
            x = numpy.where(ancilla_density_mat_diag == max_amplitude)[0][0]
        else:
            qc = self.construct_circuit(
                unitary, state_preparation, k, -2 * numpy.pi * omega_coef, measurement=True
            )
            measurements = self._quantum_instance.execute(qc).get_counts(qc)
            x = 1 if measurements.get("1", 0) > measurements.get("0", 0) else 0
        omega_coef = omega_coef + x / 2
    return omega_coef
```

According to you, is the source code above affected by the *Non-parameterized Circuit (NC)* bad practice?

[ ] Yes
[ ] No
[ ] I do not know

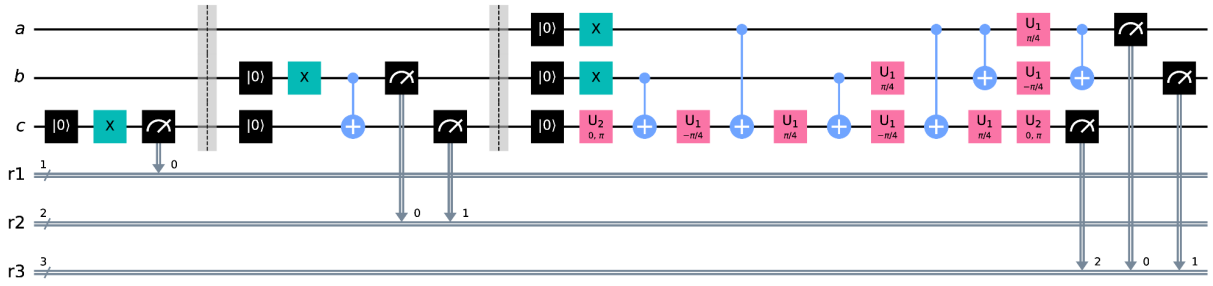
Q10 – Long Circuit (LC): Unitary gates and measurements are prone to errors (specially due to quantum noise). The higher the depth of the circuit and/or wider the circuit, the higher is the probability of affecting a quantum circuit's intended behavior.



According to you, is the quantum circuit above affected by the *Long Circuit (LC)* bad practice?

[ ] Yes
[ ] No
[ ] I do not know

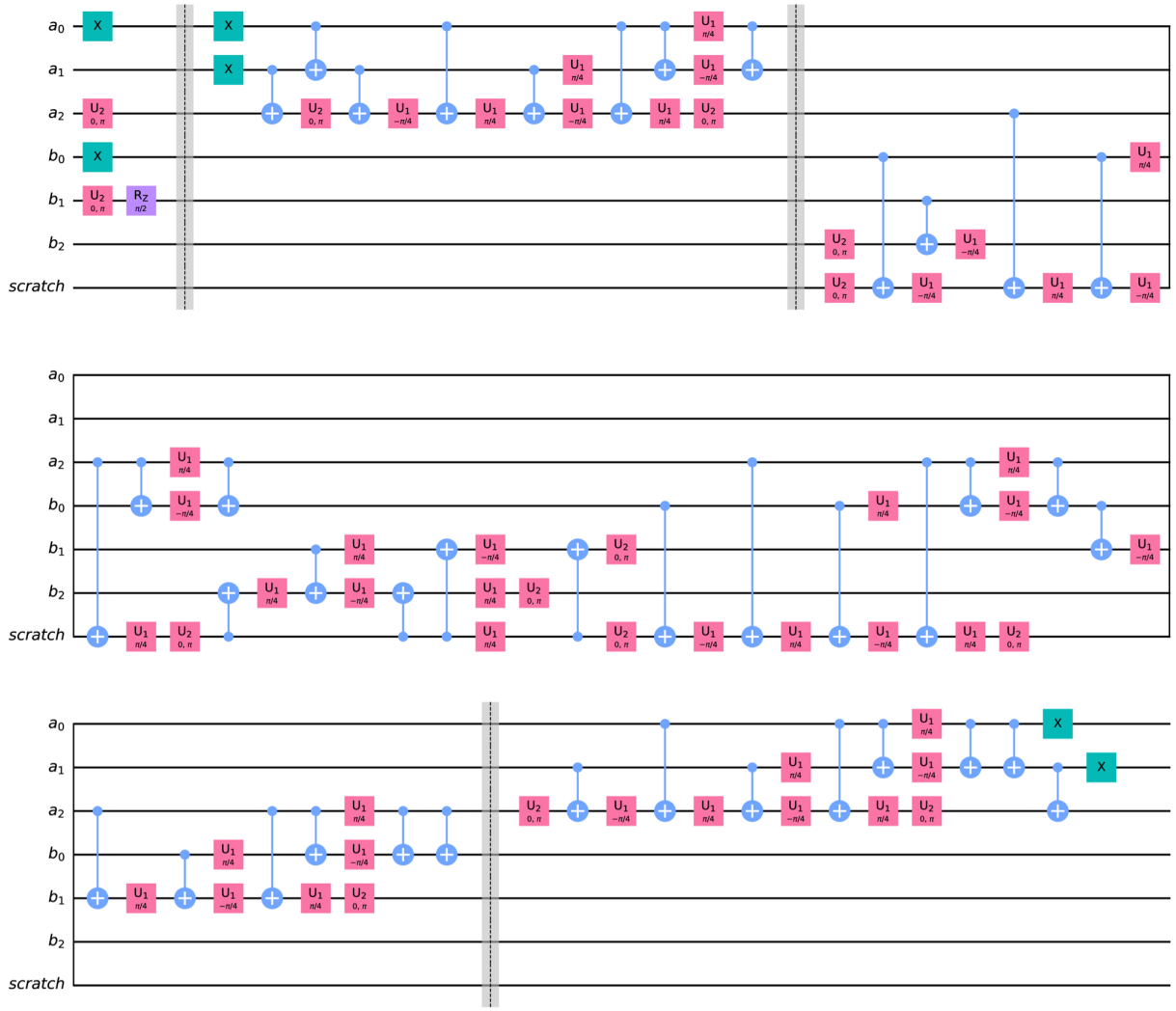
Q11 – Intermediate Measurements (IM): Intermediate measurements occur when a quantum state is measured within a quantum circuit and right after the measurement, there are still quantum operators to be performed on the circuit. As the measurement is an operation that collapses the quantum state into a classical state, intermediate measurements may provoke possible circuit errors. Therefore, measurements should be postponed to be the very last operation on the circuit to avoid error propagation.



According to you, is the quantum circuit above affected by the *Intermediate Measurements (IM)* bad practice?

[ ] Yes
[ ] No
[ ] I do not know

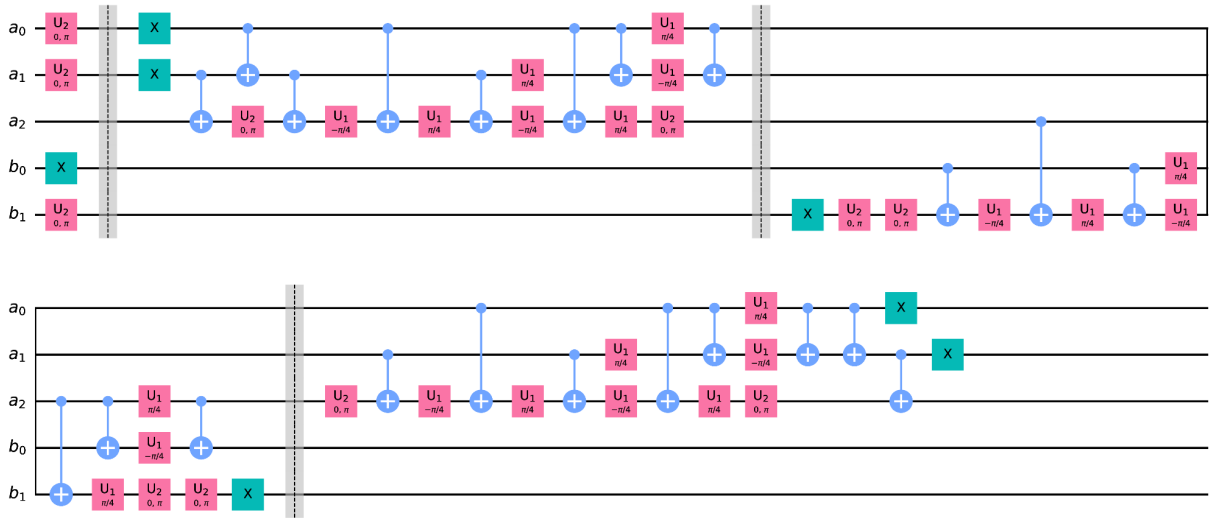
Q12 – Idle Qubits (IdQ): With current quantum technology it is only possible to ensure the correctness of a state for very short periods of time. Thus, having idle qubits for too long enhance the loss of quantum information that may jeopardize the results of a quantum circuit.



According to you, is the quantum circuit above affected by the *Idle Qubits (IdQ)* bad practice? Note: the draw of the circuit above is splitted in three to ease one to read it without having to do any horizontal scroll.

[ ] Yes
[ ] No
[ ] I do not know

Q13 – Initialization of Qubit differently from |0⟩ (IQ): Initializing qubits in a state different from |0⟩ implies putting the qubit in an excited state, i.e., in a state of non-equilibrium. A qubit in an excited state has a high chance of being altered throughout time, due to its physical properties, if it is not used for a while and therefore, the qubit's state might not be the one we want it to be when we apply an operator to it after a given time.



According to you, is the quantum circuit above affected by the *Initialization of Qubit differently from |0⟩ (IQ)* bad practice?
Note: the draw of the circuit above is splitted in two to ease one to read it without having to do any horizontal scroll.

[ ] Yes
[ ] No
[ ] I do not know

Q14 – No-alignment between the Logical and Physical Qubits (LPQ): The topology of a quantum circuit impacts its behavior, i.e., the results obtained from the circuit can change according to the physical qubits configuration. Therefore, not aligning the logical qubits to the proper physical qubits may result in the occurrence of noise. In Qiskit, for example, this can be achieved by invoking the transpile method with the parameter initial_layout set.

According to this description, do you agree the *No-alignment between the Logical and Physical Qubits (LPQ)* is a bad practice?

[ ] Yes
[ ] No
[ ] I do not know

Q15 – If you believe there are other impacts or want to add any comment regarding the bad practices mentioned above, please briefly describe: _____.

Q16 – Based on your experience and on the description of each bad practice, please rank the list of bad programming practices according to their severity being 1 is the most severe and 8 is the least severe. Multiple bad programming practices can have the same ranking.

[1, 2, 3, 4, 5, 6, 7, 8] Usage of Customized Gates (CG)
[1, 2, 3, 4, 5, 6, 7, 8] Repeated set of Operations on Circuit (ROC)
[1, 2, 3, 4, 5, 6, 7, 8] Non-parameterized Circuit (NC)
[1, 2, 3, 4, 5, 6, 7, 8] Long Circuit (LC)
[1, 2, 3, 4, 5, 6, 7, 8] Intermediate Measurements (IM)
[1, 2, 3, 4, 5, 6, 7, 8] Idle Qubits (IdQ)
[1, 2, 3, 4, 5, 6, 7, 8] Initialization of Qubit differently from $|0\rangle$ (IQ)
[1, 2, 3, 4, 5, 6, 7, 8] No-alignment between the Logical and Physical Qubits (LPQ)

Q17 – If you would like to be contacted for follow-ups to this study or know more about the outcome of this study, please provide your email address: _____.