Basics of Dart & Flutter: Part II

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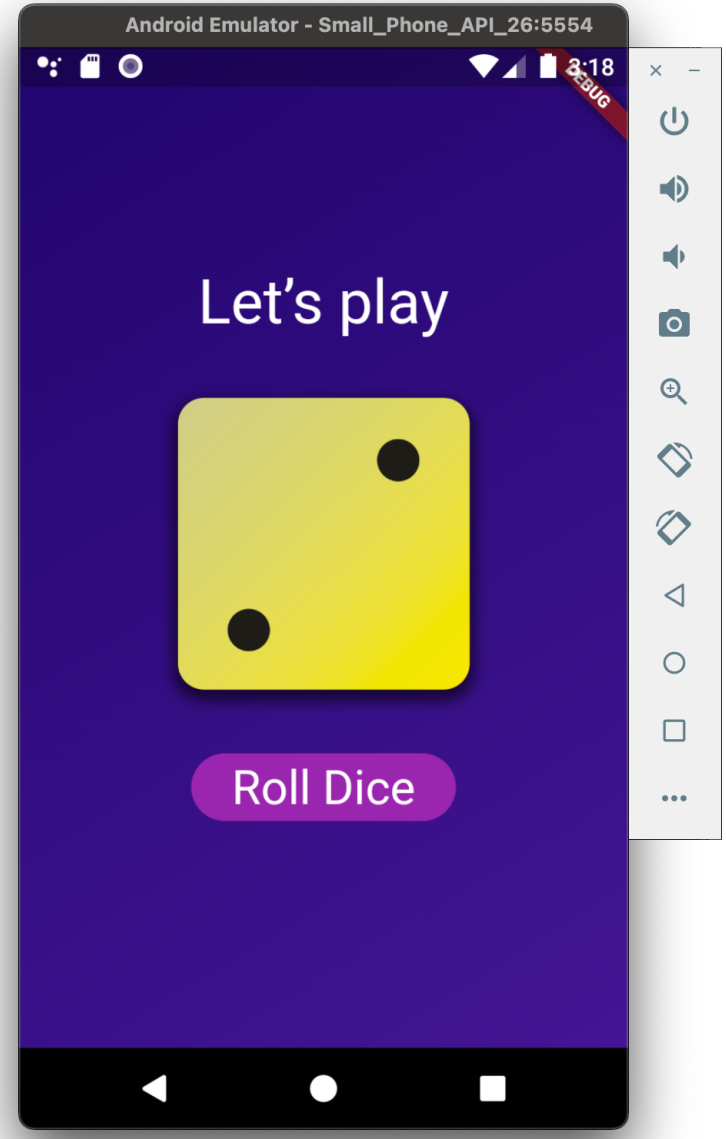
Questions?


Android Emulator - Small_Phone_API_26:5554
3:18
DEBUG
Let's play
Roll Dice

Final vs. Const

```
void main() {
  final date = DateTime.now(); // OK
  const date = DateTime.now(); // Error

  const pi = 3.14; // OK
  final gravity; // Error: must be initialized
  final gravity = Gravity();
  gravity.setForce(...) // OK
}
```

- A `final` variable can only be set once
  - Referenced object can still be mutable
- A `const` variable is a compile-time constant
  - ***Canonicalized***: only one copy in memory
  - `Const` widgets can be rebuilt faster in Flutter

Immutable Classes/Widgets

```
class ImmutablePoint {
  final double x; // or any immutable type
  final double y;

  // Const constructor
  const ImmutablePoint(this.x, this.y);
}

void main() {
  const point1 = ImmutablePoint(2, 3);
  const point2 = ImmutablePoint(2, 3);
  print(point1 == point2); // Outputs: true
  print(identical(point1, point2)); // Outputs: true

  final point3 = ImmutablePoint(2, 3);
  final point4 = ImmutablePoint(2, 3);
  print(point1 == point2); // Depends on if "==" is overridden
  print(identical(point1, point2)); // Outputs: false
}
```

- Try make `const` Widget yourself

Object or Dynamic?

```
// Map<String, dynamic> or Map<String, Object>?

void main() {
  Object obj = 'Hello';
  print(obj.length); // Compile-time error
  print((obj as String).length); // OK

  dynamic dyn = 'Hello';
  print(dyn.length); // OK
  print(dyn.isEven); // Runtime error
}
```

- `Object` offers compile-time type safety
- `dynamics` by passes compile-time type checks at the cost of runtime errors

Composite over Inheritance

```
class StyledText extends Text {
  ...
}
```

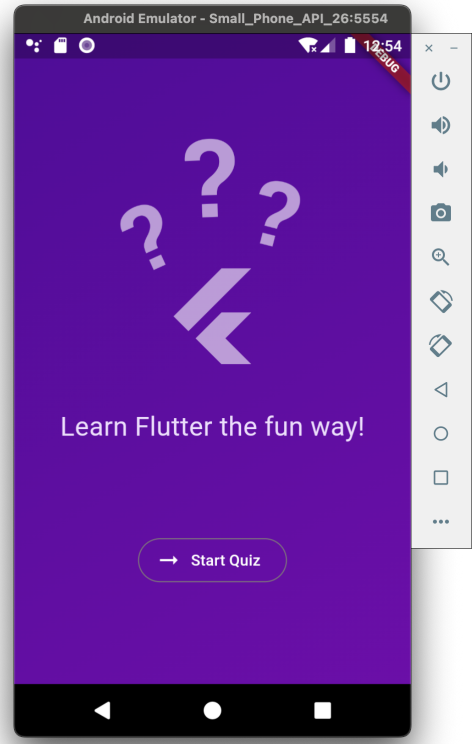
- Composition allows widgets to remain loosely coupled, promoting reusability

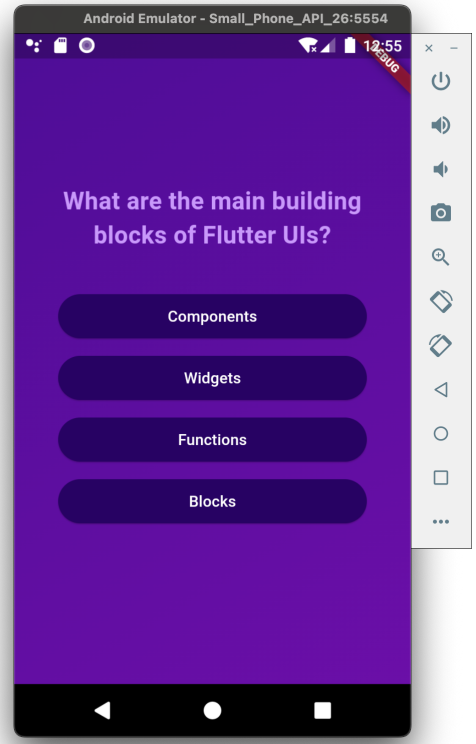
```
class StyledText extends StatelessWidget {
  final String text;
  final TextStyle style;

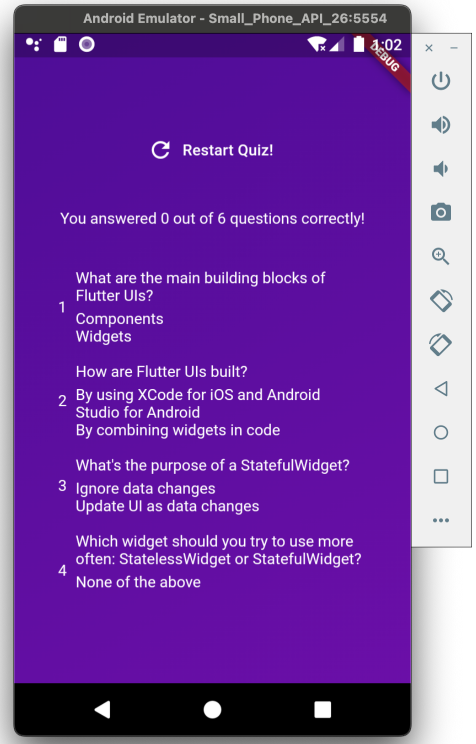
  const StyledTextComposition(this.text, {
    super.key,
    required this.style,
  });

  @override
  Widget build(BuildContext context) {
    return Text(text, style: style);
  }
}
```

Meet the Quiz App







Today's Topics

- More Dart language
  - Operators & null safety
  - More OOP
  - Control flows
  - Coding conventions
- More complex widgets
  - Interoperations between multiple widgets
  - Data models
  - Basic styling
  - Scrolling
- Dev tools

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Operators

- Most ops exist in C:

  `+`, `++`, `%`, `+=`, `==`, `&&`, etc.

- Precedence & associativity
  - ```
    print(3 + 5 * 7 * (1 - 4) % 2 << 3);
    // Prints 32
    ```

- New operators:
  - Type checking & conversion ops
  - Null-aware ops
    ```

Type Checking

```
Object obj1 = ...;
Object obj2 = ...;

if (obj1 is String) {
  ... // Do something
}
if (obj2 is! int) {
  ... // Do some other thing
}

print(obj1.runtimeType);
```

Type Conversion

- `String` to `int`:

```
int one = int.parse('1');
```

- `int` to `String`:

```
String oneStr = one.toString();
```

- `double` to `int`:

```
pi.toInt();
```

- Parent to child type:

```
Object obj = 'This is a string';
String str = obj as String;
```

Null-awareness & Safety

- By default, variables ***cannot*** hold null values
  - To minimize the chance of null pointer exception (crashes) at runtime
- Unless with `?` type or `late` keyword

```
int a = 100;    // Non-nullable
int b;          // Compile-time error
int? c;         // OK
late int d;
print(d);       // Error: must be initialized first
d = 3;
print(d);       // OK
```

Null-aware Operators

```
String? str;

print(str.length); // Compile-time error

// Prints length if not null; otherwise prints null
print(str?.length);

// Prints string if not null; otherwise 'Default'
print(str ?? 'Default');

// Assign 'Default' to str if str is null
str ??= 'Default';

// Tells compiler str is not null
int length = str!.length;
```

- Use ！with care, as it risks runtime errors

Sound Null Safety

- ***Soundness***: if compiler determines that a variable is non-nullable, then the variable can ***never*** be null at runtime

- Benefits:
  - Eliminating null checks at runtime
  - Optimized inline caching and type specialization
  - Code size reduction
  - Faster hot reload

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More OOP

- Static class members
- Enums
- Abstract classes
- Annotations
- Mixins
- Extensions

Static Class Members

```
class Circle {
  static const double pi = 3.14159;
  double radius;

  Circle(this.radius);

  double area() {
    return pi * radius * radius;
  }

  double circumference() {
    return 2 * pi * radius;
  }
}

void main() {
  print(Circle.pi);
  print(Circle(5.0).area());
  print(Circle(8.0).circumference());
}
```

- Static members are shared between all instances

Enums

```
enum Status { loading, success, error }

void main() {
  var status = Status.loading;

  print(status.name); // to String

  switch(status) {
    case Status.loading:
      ...
      break;
    case Status.success:
      ...
      break;
    default:
      ...
  }
}
```

Abstract Classes

- There's no `interface` keyword in Dart

```
abstract class GameCharacter {
  String name;

  GameCharacter(this.name);

  // Must be implemented by subclasses
  void performAbility();
}

class Warrior extends GameCharacter {
  Warrior(String name) : super(name);

  @override
  void performAbility() {
    print('$name swings sword!');
  }
}

class Mage extends GameCharacter {
  Mage(String name) : super(name);

  @override
  void performAbility() {
    print('$name casts a spell!');
  }
}
```

Annotations

- Metadata for compilers and other tools

```
class Vehicle {
  // not to be overridden
  @nonVirtual
  void startEngine() {
    ...
  }
}

class Car extends Vehicle {
  // Error
  @override
  void startEngine() {
    ...
  }
}
```

```
class Animal {
  // available in this & subclass
  @protected
  void breathe() {
    print('Breathing');
  }
}

class Human extends Animal {
  void meditate() {
    breathe(); // OK
  }
}

void main() {
  Human human = Human();
  human. meditate(); // OK
  human.breathe(); // Error
}
```

Mixins

```
mixin Logger {
  void log(String message) {
    // persist message
  }
}

class OrderProcessor extends Processor with Logger, ... {
  void createOrder(String details) {
    ...
    log('Order created: $details');
  }
}
```

- A means of implementing multiple inheritance

Extensions

```
extension EmailValidator on String {
  bool get isValidEmail {
    return RegExp(
      r'^[a-zA-Z0-9.]+@[a-zA-Z0-9]+\.[a-zA-Z]+',
    ).hasMatch(this);
  }
}

void main() {
  var email = 'example@example.com';
  if (email.isValidEmail) {
    ...
  }
}
```

- Add new functionalities to existing classes without subclassing

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Control Flows

- Similar to those in C, C++ and Java

- With some additions

```
for (var e in myList) {
  ...
}
```

Switch Expressions

```
void main() {
  var char = ';';
  var token = switch (char) {
    '+'  || '-' || '*' || '/' => 'Operator',
    ','  || ';' => 'Punctuation',
    '0' || '1' || '2' || '3' || '4' || '5' || '6' ||
        '7' || '8' || '9' => 'Number',
    _ => throw FormatException('Invalid character'),
  };
  ...
}
```

- Evaluated to a single value

Spread, `if` and `for` in Collection Literals

```
bool includeOddNumbers = true;
var numbers = [1, 2, 3, 4, 5];
var evenNumbers = [2, 4];

var combinedList = [
  // Conditionally add items to list
  if (includeOddNumbers) ...numbers.where((n) => n.isOdd),

  // Iterate and add items
  for (var n in evenNumbers) n,
];

print(combinedList); // Prints what?
```

- Body needs to be single-line expression

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Styles & Conventions

- Variable/function names: `lowerCamelCase`
- Class/extension names: `UpperCamelCase`
- Package names: `snake_case`
- Import `dart:` before other imports
  - Sort each section alphabetically
- Leading underscore only for private identifiers: `_age`
- Use single-quoted strings: `'...'`
  - Exception: `"... 'single-quoted content' ..."`
- Abbreviations: `HttpConnection`, `DBPort`, `UserId`
- `_` and `__` for unused callback parameters:

```
numbers.forEach((_) {
  ...
});
```

Comments

- Single-line: `// Single-line comment.`
- Multi-line: `/* Multi-line comment. */`
- Documentation:

```
/// Calculates the area of a rectangle.
///
/// [width] the width of the rectangle.
/// [height] the height of the rectangle.
///
/// Returns the calculated area as a double.
///
/// Throws an [ArgumentError] if [width] or [height] is negative.
double calculateArea(double width, double height) {
  if (width < 0 || height < 0) {
    throw ArgumentError('Width and height must be non-negative.');
  }
  return width * height;
}
```

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Quiz App

- Dev tool: Inspector
- Image opacity
- Navigation
- Data models
- Styling
- Lists
- Scrolling

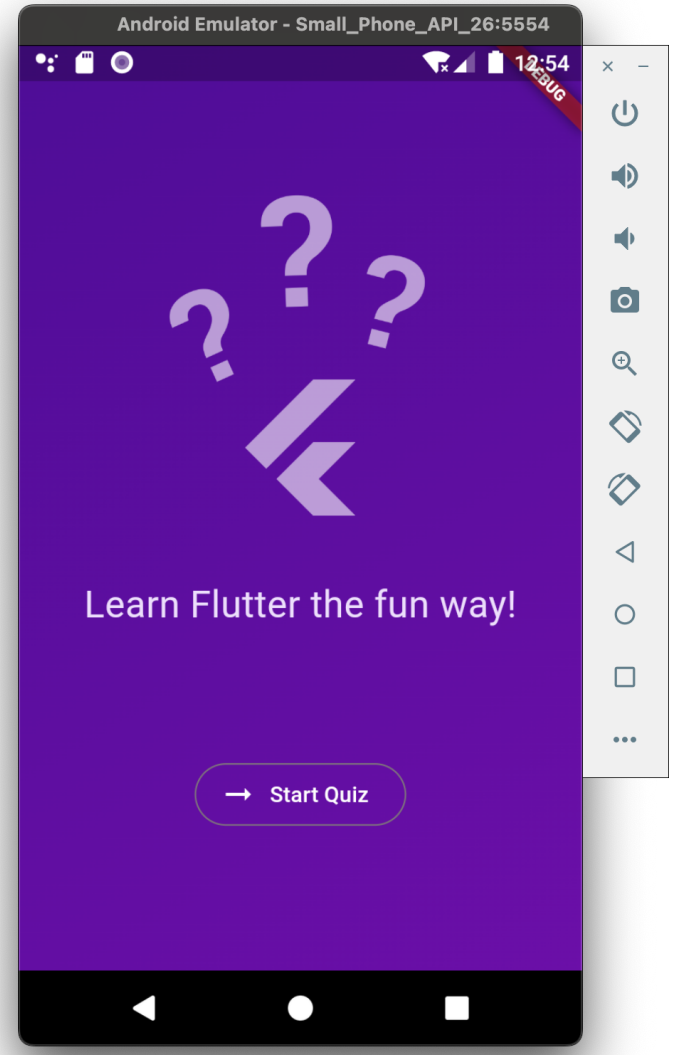


Image Opacity in `StartScreen`

- Using `Opacity` widget
  - Applies to entire subtree under `child`
  - Subtree first rendered to offscreen buffer
  - Then transformation applied
- Using the `color` property of `Image`
  - Flutter applies color as tint
  - Part of the image rendering process
  - Can be accelerated by GPU

Navigation & State Lifting

- How does the "Start" button in `StartScreen` triggers screen transition?

1. ***Lift up*** navigation state to a shared parent widget `Quiz`
2. Define callback that changes state, and pass it to `StartScreen` ***as closure***

- Same strategy is used to pass selected answers from `QuestionsScreen` to `ResultsScreen`

Stateful Widget Lifecycle

```
class TimerWidget extends StatefulWidget { ... }

class _TimerWidgetState extends State<TimerWidget> {
  int _counter = 0;
  late Timer _timer; // Cannot be initialized here

  @override
  void initState() { // Called when inserted into widget tree
    super.initState();
    _timer = Timer.periodic(Duration(seconds: 1), (timer) {
      setState(() { _counter++; });
    });
  }

  @override
  Widget build(BuildContext context) { ... }

  @override
  void dispose() { // Called when removed from widget tree
    _timer.cancel(); // Prevent memory leaks
    super.dispose();
  }
}
```

Data Models

- Plain old Dart objects (PODO) holding app's data structure
- No business logics
  - E.g., persistence, authentication, etc.
- Can be immutable
- Can have ***getter*** and ***setter*** methods to control access

```
class User {
  User(this._name, this._age);

  String _name; // private
  String get name => _name; // getter
  set name(String newName) { // setter
    if (newName.isNotEmpty) {
      _name = newName;
    } else {
      print('Name cannot be empty');
    }
  }
  int _age; // private
  int get age => _age; // getter
  set age(int newAge) { // setter
    if (newAge > 0) {
      _age = newAge;
    } else {
      print('Age must be > 0');
    }
  }
}
...
var name = user.name; // call getter
user.age = 20; // call setter
```

Styling

- Google font used in `questions_screen.dart` to make questions stand out
- Rounded corners and centered text for `answer_button.dart`
- Icons in “Start” and “Restart” buttons
  - See all available material icons

Filtering & Analyzing Lists

```
// in results_screen.dart
final List<Map<String, Object>> summaryData = ...;
final numTotalQuestions = questions.length;
final numCorrectQuestions = summaryData.where((data) {
  return data['user_answer'] == data['correct_answer'];
}).length;
```

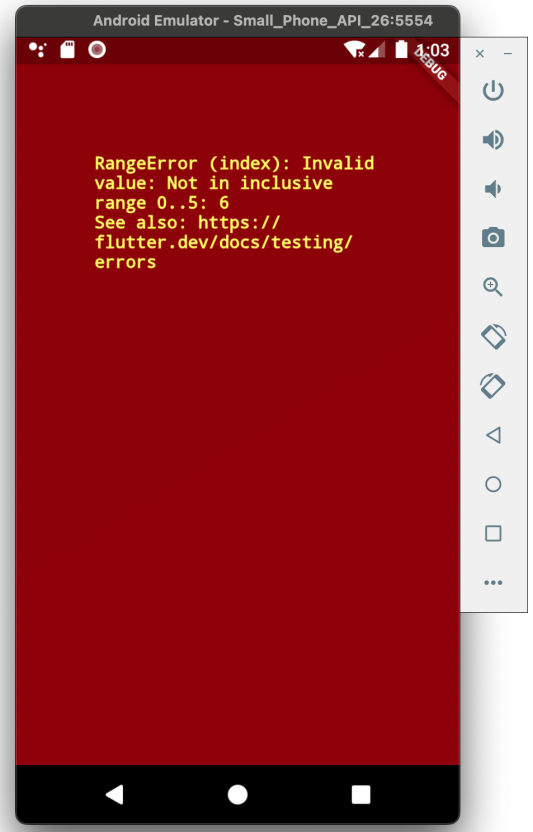
- `where` filters the list and results an `Iterable`

Scrolling

- Watchout the ***overflow*** issues
- Try removing `Expand` and `SingleChildScrollView` widgets in `questions_summary.dart`

- In Flutter, overflowed widgets are ***not*** wrapped nor scrollable by default

The Code We Release will be Buggy!



- Learn how to debug in the next lab

References

- Introduction to Dart