

REFRAMING PROGRAMMING PEDAGOGY

Understanding Challenges Novices Face
and How Teaching Must Change





INFORMATION
TECHNOLOGY
UNIVERSITY

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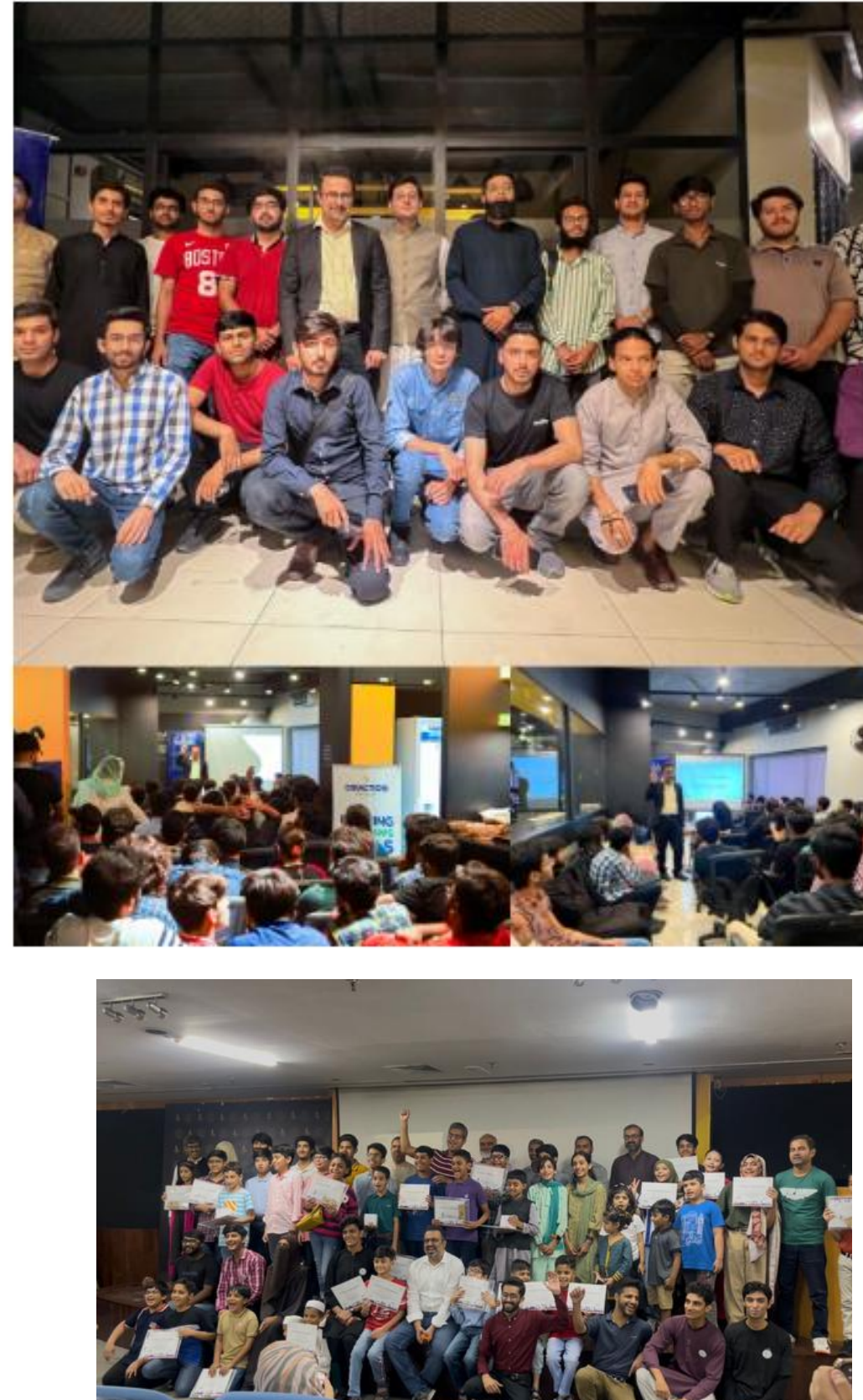
Abdul Basit



Ahmed



Moments



Reframing Programming Pedagogy Understanding challenges novices face and how Teaching Must Change

~ Sarfraz Raza

Novice Learners at Different Stages

Primary School
K3–K6

High School
K6–K12

Undergrad
Tertiary level



~30-50% Students Dropped-Out After Starting CS Degree

**Schefer-Wenzl, Sigrid, et al. "A study on reasons for student dropouts in a computer science bachelor's degree program."
International Conference on Interactive Collaborative Learning. Cham: Springer Nature Switzerland, 2023.**



5-10%

Students are employable



Teacher

Instructional Design
Challenges

GAP

Student

Learning
Challenges

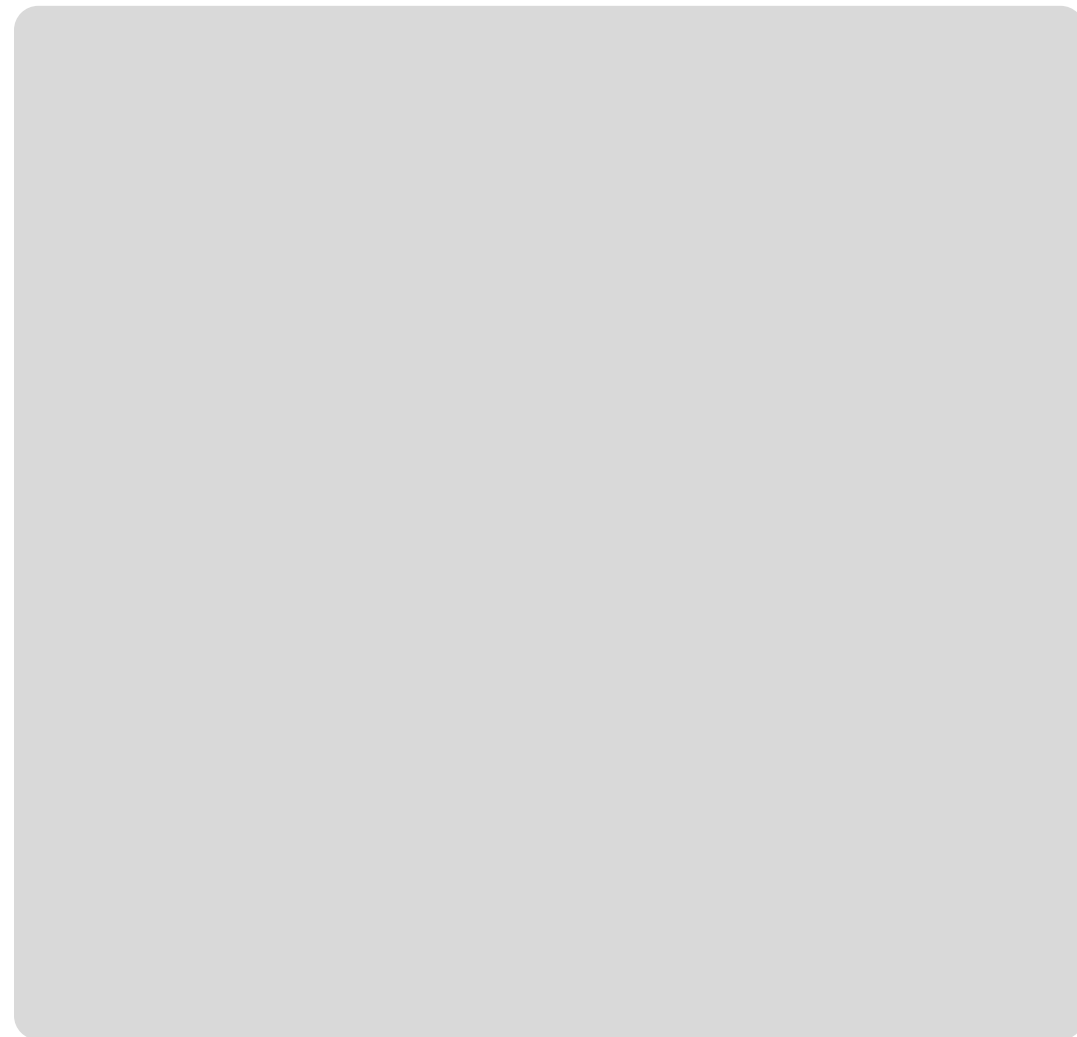
Teacher

GAP

Student

Understanding the
Sequential Execution

Sequential Execution



Program



Step-by-Step
Execution
(With Watches)

Debugger



Dry Run

On Paper



FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3(Global Scope)main()

1#include <iostream>

2#include <string>

3using namespace std;

4

5int main() {

6▶ int math = 85, science = 74, english = 91;

7int total = math + science + english; ≤ 1ms elapsed

8float average = total / 3;

9cout << "Total Marks: " << total << endl;

10cout << "Average Marks: " << average << endl;

11string grade;

12if (average >= 90)

13 grade = "A+";

14else if (average >= 80)

15 grade = "A";

16else if (average >= 70)

17 grade = "B";

18else

19 grade = "C";

20cout << "Grade: " << grade << endl;

21return 0;

22}

Locals

Search (Ctrl+E)

Name	Value
average	-1073741...
english	91
grade	<Error re...
math	85
science	74
total	-8589934...

124 %No issues foundLn: 7Ch: 1SPCCRLF

Call StackBreakpointsException SettingsCommand WindowImmediate WindowOutput

ReadyAdd to Source ControlSelect Repository

Sequential Execution

Step-by-Step Execution

math	science	english	total	average	grade
85	74	91	-	-	-

Dry Run

Microsoft Visual Studio Debug Console



FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3(Global Scope)main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search (Ctrl+E)

Name	Value
average	-1073741...
english	91
grade	<Error re...
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-

Dry Run

Microsoft Visual Studio Debug Console



FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

1#include <iostream>

2#include <string>

3using namespace std;

4

5int main() {

6int math = 85, science = 74, english = 91;

7int total = math + science + english;

8float average = total / 3;

9cout << "Total Marks: " << total << endl;

10cout << "Average Marks: " << average << endl;

11string grade;

12if (average >= 90)

13grade = "A+";

14else if (average >= 80)

15grade = "A";

16else if (average >= 70)

17grade = "B";

18else

19grade = "C";

20cout << "Grade: " << grade << endl;

21return 0;

22}

Locals

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	<Error re...
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console



FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelp

SearchConsoleApplication3

Process: [15464] ConsoleApplication3.exe Lifecycle Events Thread: [18932] Main Thread Stack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3 (Global Scope) main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search Depth: 3 Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	<Error re...
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 % No issues found

Ln: 10 Ch: 1 SPC CRLF

Call Stack Breakpoints Exception Settings Command Window Immediate Window Output

Ready

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelp

SearchConsoleApplication3

Process: [15464] ConsoleApplication3.exe Lifecycle Events Thread: [18932] Main Thread Stack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3 (Global Scope) main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	<Error re...
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 % No issues found

Ln: 11 Ch: 1 SPC CRLF

Autos Locals Watch 1 Watch 2

Call Stack Breakpoints Exception Settings Command Window Immediate Window Output

Ready Add to Source Control Select Repository

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250
Average Marks: 83

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

12345678910111213141516171819202122

```
#include <iostream>
#include <string>
using namespace std;

int main() {
    int math = 85, science = 74, english = 91;
    int total = math + science + english;
    float average = total / 3;
    cout << "Total Marks: " << total << endl;
    cout << "Average Marks: " << average << endl;
    string grade;
    if (average >= 90)
        grade = "A+";
    else if (average >= 80)
        grade = "A";
    else if (average >= 70)
        grade = "B";
    else
        grade = "C";
    cout << "Grade: " << grade << endl;
    return 0;
}
```

Locals

Search Depth: 3

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	""
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 %No issues foundLn: 12Ch: 1SPCCRLF

Call StackBreakpointsException SettingsCommand WindowImmediate WindowOutput

ReadyAdd to Source ControlSelect Repository

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250

Average Marks: 83

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelp

SearchConsoleApplication3

Process: [15464] ConsoleApplication3.exe Lifecycle Events Thread: [18932] Main Thread Stack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3 (Global Scope) main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	""
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 % No issues found

Ln: 14 Ch: 1 SPC CRLF

AutosLocalsWatch 1Watch 2

Call StackBreakpointsException SettingsCommand WindowImmediate WindowOutput

Ready Add to Source Control Select Repository

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250
Average Marks: 83

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3(Global Scope)main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	""
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 %No issues foundLn: 15 Ch: 1 SPC CRLF

Call StackBreakpointsException SettingsCommand WindowImmediate WindowOutput

ReadyAdd to Source ControlSelect Repository

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250
Average Marks: 83

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3(Global Scope)main()

1#include <iostream>

2#include <string>

3using namespace std;

4

5int main() {

6int math = 85, science = 74, english = 91;

7int total = math + science + english;

8float average = total / 3;

9cout << "Total Marks: " << total << endl;

10cout << "Average Marks: " << average << endl;

11string grade;

12if (average >= 90)

13grade = "A+";

14else if (average >= 80)

15grade = "A";

16else if (average >= 70)

17grade = "B";

18else

19grade = "C";

20cout << "Grade: " << grade << endl;

21return 0;

22}

Locals

Search (Ctrl+E)

Name	Value
average	83.00000...
english	91
grade	"A"
math	85
science	74
total	250

Sequential Execution

Step-by-Step Execution

124 %No issues foundLn: 20Ch: 1SPCCRLF

Call StackBreakpointsException SettingsCommand WindowImmediate WindowOutput

ReadyAdd to Source ControlSelect Repository

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-
85	74	91	250	83.00	A

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250

Average Marks: 83

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelpSearchConsoleApplication3

Process: [15464] ConsoleApplication3.exeLifecycle EventsThread: [18932] Main ThreadStack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3(Global Scope)main()

1#include <iostream>

2#include <string>

3using namespace std;

4

5int main() {

6int math = 85, science = 74, english = 91;

7int total = math + science + english;

8float average = total / 3;

9cout << "Total Marks: " << total << endl;

10cout << "Average Marks: " << average << endl;

11string grade;

12if (average >= 90)

13grade = "A+";

14else if (average >= 80)

15grade = "A";

16else if (average >= 70)

17grade = "B";

18else

19grade = "C";

20cout << "Grade: " << grade << endl;

21return 0; ≤ 2ms elapsed

22}

Locals

Search (Ctrl+E)

NameValue

average83.00000...

english91

grade"A"View

math85

science74

total250

Sequential Execution

Step-by-Step Execution

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-
85	74	91	250	83.00	A

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250

Average Marks: 83

Grade: A

FileEditViewGitProjectBuildDebugTestAnalyzeToolsExtensionsWindowHelp

SearchConsoleApplication3

Process: [15464] ConsoleApplication3.exe Lifecycle Events Thread: [18932] Main Thread Stack Frame: main

ConsoleApplication3.cpp

ConsoleApplication3 (Global Scope) main()

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average >= 90)
13        grade = "A+";
14    else if (average >= 80)
15        grade = "A";
16    else if (average >= 70)
17        grade = "B";
18    else
19        grade = "C";
20    cout << "Grade: " << grade << endl;
21    return 0;
22 }
```

Locals

Search (Ctrl+E)

Name	Value
main w...	0
average	83.00000...
english	91
grade	""
math	85
science	74
total	250

124%

No issues found

Ln: 22 Ch: 1 SPC CRLF

AutosLocalsWatch 1Watch 2

Ready

Add to Source ControlSelect Repository

Sequential Execution

Step-by-Step Execution

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-
85	74	91	250	83.00	A

Dry Run

Microsoft Visual Studio Debug Console

Total Marks: 250
Average Marks: 83
Grade: A

File Edit View Git Project Build Debug Test Analyze Tools Extensions Window Help Search ConsoleApplication3

Process: [15464] ConsoleApplication3.exe Lifecycle Events Thread: [18932] Main Thread Stack Frame: main

ConsoleApplication3.cpp

```
1 #include <iostream>
2 #include <string>
3 using namespace std;
4
5 int main() {
6     int math = 85, science = 74, english = 91;
7     int total = math + science + english;
8     float average = total / 3;
9     cout << "Total Marks: " << total << endl;
10    cout << "Average Marks: " << average << endl;
11    string grade;
12    if (average < 60)
13        grade = "F";
14    else if (average < 70)
15        grade = "D";
16    else if (average < 80)
17        grade = "C";
18    else if (average < 90)
19        grade = "B";
20    else
21        grade = "A";
22    cout << "Grade: " << grade << endl;
23    return 0;
24 }
```

Locals

Name	Value
main w...	0
average	83.00000...
english	91
grade	"A"
math	85
science	74
total	250

124 % No issues found Ln: 22 Ch: 1 SPC CRLF Autos Locals Watch 1 Watch 2

Ready Add to Source Control Select Repository

Seeing is Believing

math	science	english	total	average	grade
85	74	91	-	-	-
85	74	91	250	-	-
85	74	91	250	83.00	-
85	74	91	250	83.00	A

Microsoft Visual Studio Debug Console

```
Total Marks: 250
Average Marks: 83
Grade: A
```

Teacher

GAP

Student

Control Structures
Difficulties

Control Structures Difficulties

- **If** Statement
- **If else** statement
- **switch** statement

Control Structures

and &&
or ||
not !

Compound Statements



Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

if(_____):
    if(country == "US"):
        print(f"Your balance in USD is {balance*0.0035}")
    elif(country == "India"):
        print(f"Your balance in INR is {balance*0.30}")
    elif(country == "Iran"):
        print(f"Your balance in Irani Rial is {balance*148.49}")
else:
    print("Wrong country....")
```

Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

if(country=="US" or country == "India" or country == "Iran"):
    if(country == "US"):
        print(f"Your balance in USD is {balance*0.0035}")
    elif(country == "India"):
        print(f"Your balance in INR is {balance*0.30}")
    elif(country == "Iran"):
        print(f"Your balance in Irani Rial is {balance*148.49}")
else:
    print("Wrong country....")
```

Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

while(_____):
    country = input("Wrong Country! Enter Again: ")

if(country == "US"):
    print(f"Your balance in USD is {balance*0.0035}")
elif(country == "India"):
    print(f"Your balance in INR is {balance*0.30}")
elif(country == "Iran"):
    print(f"Your balance in Irani Rial is {balance*148.49}")
```


Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

while(country != "US" or country != "India" or country != "Iran"):
    country = input("Wrong Country! Enter Again: ")

if(country == "US"):
    print(f"Your balance in USD is {balance*0.0035}")
elif(country == "India"):
    print(f"Your balance in INR is {balance*0.30}")
elif(country == "Iran"):
    print(f"Your balance in Irani Rial is {balance*148.49}")
```

Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

while(country!="US" and country!="India" and country!="Iran"):
    country = input("Wrong Country! Enter Again: ")

if(country == "US"):
    print(f"Your balance in USD is {balance*0.0035}")
elif(country == "India"):
    print(f"Your balance in INR is {balance*0.30}")
elif(country == "Iran"):
    print(f"Your balance in Irani Rial is {balance*148.49}")
```

Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
country = input("Where you wanna go? ")

while(not(country=="US" or country=="India" or country=="Iran")):
    country = input("Wrong Country! Enter Again: ")

if(country == "US"):
    print(f"Your balance in USD is {balance*0.0035}")
elif(country == "India"):
    print(f"Your balance in INR is {balance*0.30}")
elif(country == "Iran"):
    print(f"Your balance in Irani Rial is {balance*148.49}")
```


Compound Conditions

You have a balance in PKR. You got a visa for India, Iran, and the US. What will be your balance in these countries ?

```
balance = int(input("Enter balance (PKR): "))
```

```
country = input("Where you wanna go? ")
```

```
while(not(country=="US" or country=="India" or country=="Iran")):
```

```
|     country = input("Wrong Country! Enter Again: ")
```

```
if(country == "US"):
```

```
|     print(f"Your balance in USD is {balance*0.0035}")
```

```
elif(country == "India"):
```

```
|     print(f"Your balance in INR is {balance*0.30}")
```

```
elif(country == "Iran"):
```

```
|     print(f"Your balance in Irani Rial is {balance*148.49}")
```

Essential to explain DeMorgan's law
for clarity on compound statements

$$(A \cup B)' = A' \cap B'$$

Teacher

GAP

Student

Control Structures Difficulties
(Discovering **loop structure**)

Finding maximum of 5 numbers

5 ifs - 5 condition per if

Approach 1

```
int N1, N2, N3, N4, N5, max;
cin >> N1 >> N2 >> N3 >> N4 >> N5;

if (N1 >= N2 && N1 >= N3 && N1 >= N4 && N1 >= N5)
    max = N1;
else if (N2 >= N1 && N2 >= N3 && N2 >= N4 && N2 >= N5)
    max = N2;
else if (N3 >= N1 && N3 >= N2 && N3 >= N4 && N3 >= N5)
    max = N3;
else if (N4 >= N1 && N4 >= N2 && N4 >= N3 && N4 >= N5)
    max = N4;
else if (N5 >= N1 && N5 >= N2 && N5 >= N3 && N5 >= N4)
    max = N5;
cout << "The max is " << max << endl;
```

Finding maximum of 5 numbers

5 ifs - decreasing conditions per if

Approach 2

```
int N1, N2, N3, N4, N5, max;
cin >> N1 >> N2 >> N3 >> N4 >> N5;

if (N1 >= N2 && N1 >= N3 && N1 >= N4 && N1 >= N5)
    max = N1;
else if (N2 >= N3 && N2 >= N4 && N2 >= N5)
    max = N2;
else if (N3 >= N4 && N3 >= N5)
    max = N3;
else if (N4 >= N5)
    max = N4;
else
    max = N5;
cout << "The max is " << max << endl;
```


Finding maximum of 5 numbers

Remembering the maximum

Approach 3

```
int N1, N2, N3, N4, N5, max;
cin >> N1 >> N2 >> N3 >> N4 >> N5;

max = N1;
if (N2 >= max)
    max = N2;
if (N3 >= max)
    max = N3;
if (N4 >= max)
    max = N4;
if (N5 >= max)
    max = N5;
cout << "The max is " << max << endl;
```

Finding maximum of 5 numbers

Reusing the variable

Approach 4

```
int N,max;
cin >> N;
max = N;

cin >> N;
if (N >= max)
    max = N;
cin >> N;
if (N >= max)
    max = N;
cin >> N;
if (N >= max)
    max = N;
cin >> N;
if (N >= max)
    max = N;
cout << "The max is " << max << endl;
```

Finding maximum of 5 numbers

Reusing the variable

Approach 4

```
int N,max;  
cin >> N;  
max = N;
```

```
cin >> N;  
if (N >= max)  
    max = N;
```

```
cin >> N;  
if (N >= max)  
    max = N;
```

```
cin >> N;  
if (N >= max)  
    max = N;
```

```
cin >> N;  
if (N >= max)  
    max = N;
```

```
cout << "The max is " << max << endl;
```

Finding maximum of 5 numbers

Using for loop

Approach 5

```
int N,max;
cin >> N;
max = N;
for(int i=2; i<=5; i++){
    cin >> N;
    if (N >= max)
        max = N;
}
cout << "The max is " << max << endl;
```


Teacher

GAP

Student

Nested Control Structures

Nested Control Structures

- `if { if {...} }`
- `if { if {...} else if {...} }`
- `if { for {...} }`
- `for { if {...} }`
- `for { for {...} }`
- `for { while {...} }`

Assuming all variations is unreasonable



Teacher

GAP

Student

Nested Control Structures
(Lets see one Example)

Nested Control Structures

N is composite if it is divided by any number between 2 and N – 1.

```
bool isComposite(int N){  
    for (int d = 2; d <= N - 1; d++)  
        if (N % d == 0)  
            return true;  
    return false;  
}
```

Composite Number

$$(\exists d \in \mathbb{Z}, 2 \leq d \leq N - 1 \text{ such that } d \mid N)$$

Nested Control Structures

N is prime if it is not divided by any number between 2 and N – 1.

```
bool isPrime(int N){  
    for (int d = 2; d <= N - 1; d++)  
        if (N % d != 0)  
            return true;  
    return false;  
}
```

Prime Number

$$\neg (\exists d \in \mathbb{Z}, 2 \leq d \leq N - 1 \text{ such that } d \mid N)$$

Which is logically equivalent to:

$$\forall d \in \mathbb{Z}, 2 \leq d \leq N - 1 \Rightarrow d \nmid N$$

Nested Control Structures

N is prime if it is not divided by any number between 2 and N – 1.

Prime Number

```
bool isPrime(int N){  
    for (int d = 2; d <= N - 1; d++)  
        if (N % d == 0)  
            return false;  
    return true;  
}
```

So Why This now?

**Looking for a
Counter Example**

$$\neg (\exists d \in \mathbb{Z}, 2 \leq d \leq N - 1 \text{ such that } d \mid N)$$

Which is logically equivalent to:

$$\forall d \in \mathbb{Z}, 2 \leq d \leq N - 1 \Rightarrow d \nmid N$$

There exists vs For All:

- **There exists** leads to a proof search
- **For All** leads to a counter example search



Another Challenge - Interpretation

```
bool isPrime(int N){  
    for (int d = 2; d <= N - 1; d++){  
        if (N % d == 0)  
            return false;  
        else  
            return true;  
    }  
    return true;  
}
```

$$\forall d \in \mathbb{Z}, 2 \leq d \leq N - 1 \Rightarrow d \nmid N$$



Another Challenge - Testing

```
bool isPrime(int N){  
    for (int d = 2; d <= N - 1; d++){  
        if (N % d == 0)  
            return false;  
        else  
            return true;  
    }  
    return true;  
}
```

Lets test this code for N={2,3,4,5,6,7,8,9}



Another Challenge - Testing

```
bool isPrime(int N){  
    for (int d = 2; d <= N - 1; d++){  
        if (N % d == 0)  
            return false;  
        else  
            return true;  
    }  
    return true;  
}
```

Why Hackerrank-like automated checking should be Introduced??

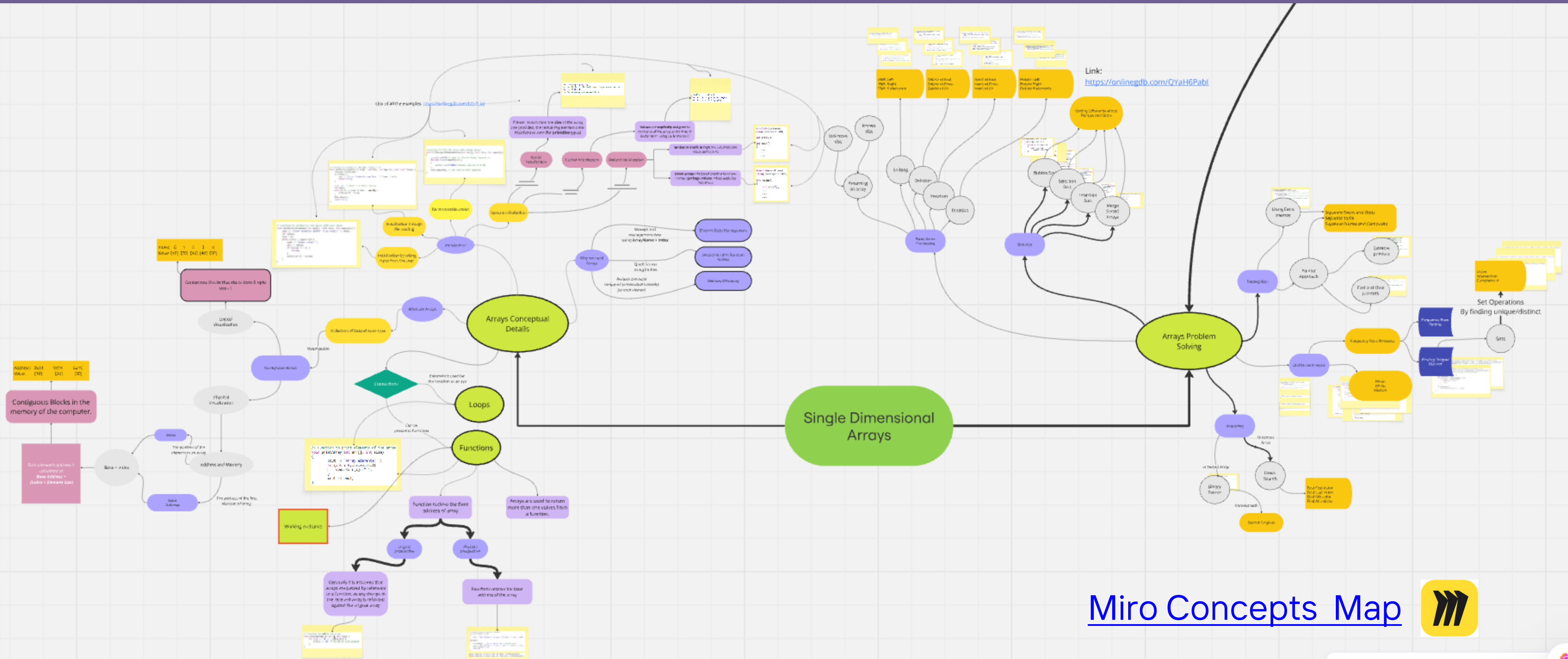


Difficulties At every level

An urgency to look into the details.

- Functions
- **Single-Dimensional Arrays**
- Pointers
- Dynamic Memory Allocations
- Multidimensional Arrays and their several traversals
- Structures
- ...

Single-Dimensional Arrays



What is the objective of Programming Fundamentals?

Learn to build Step by Step Bigger Projects

Examples:

1. Gomoku
2. Game of Life
3. Snakes and Ladders
4. Nokia Snake
5. Chess (Now expect them to do Chess)



What is the objective of Programming Fundamentals?

Learn to build Step by Step Bigger Projects

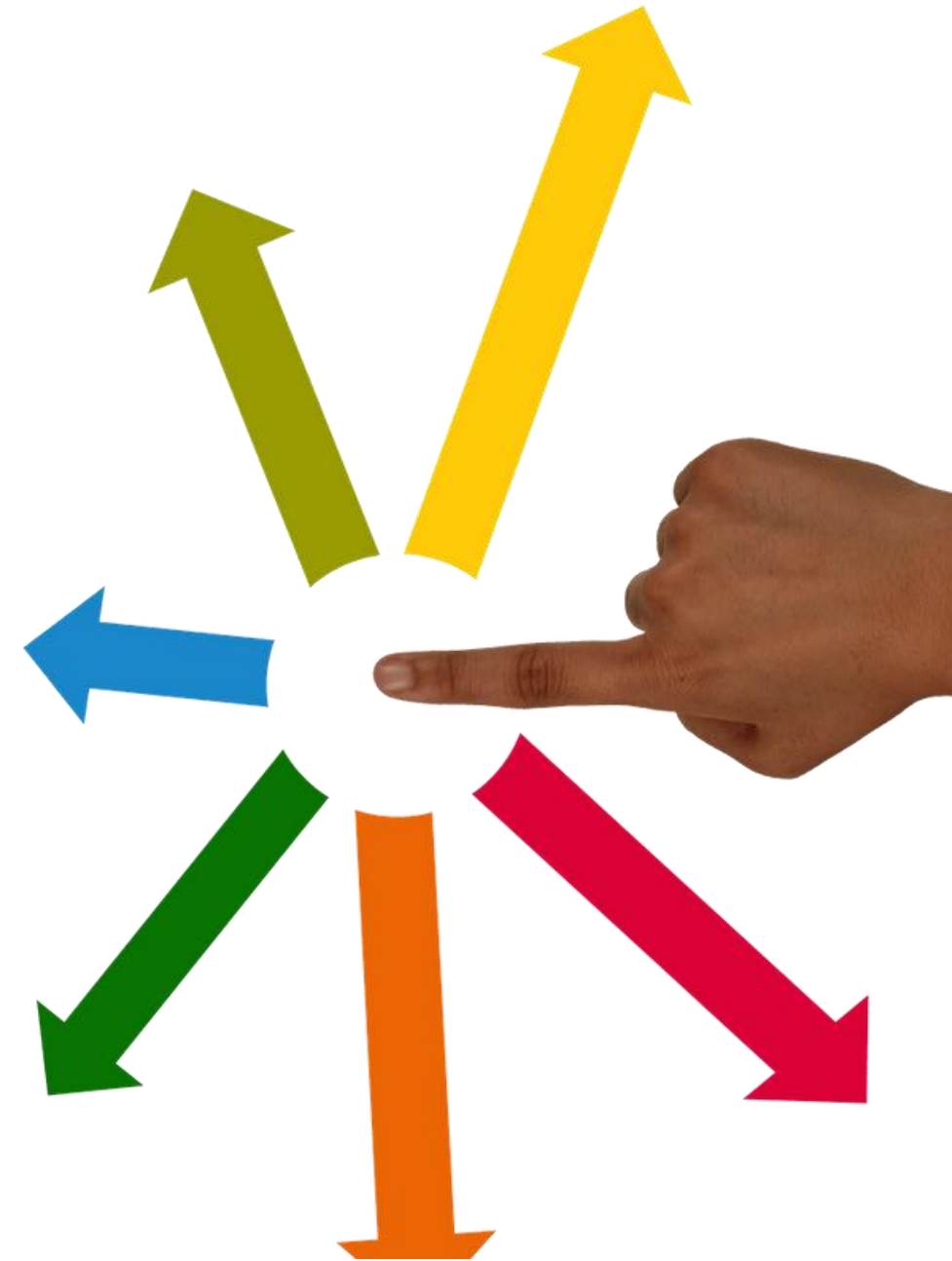
Examples:

1. Gomoku
2. Game of Life
3. Snakes and Ladders
4. Nokia Snake
5. Chess (Now expect them to do Chess)

**“Unfair to assess ,
DIVIDE and CONQUER,
without a walkthrough!”**



One-way teaching
DOES NOT work for **ALL?**
(from **undergrad** to **high-school**)



Pattern Printing

Undergrad Students process this very

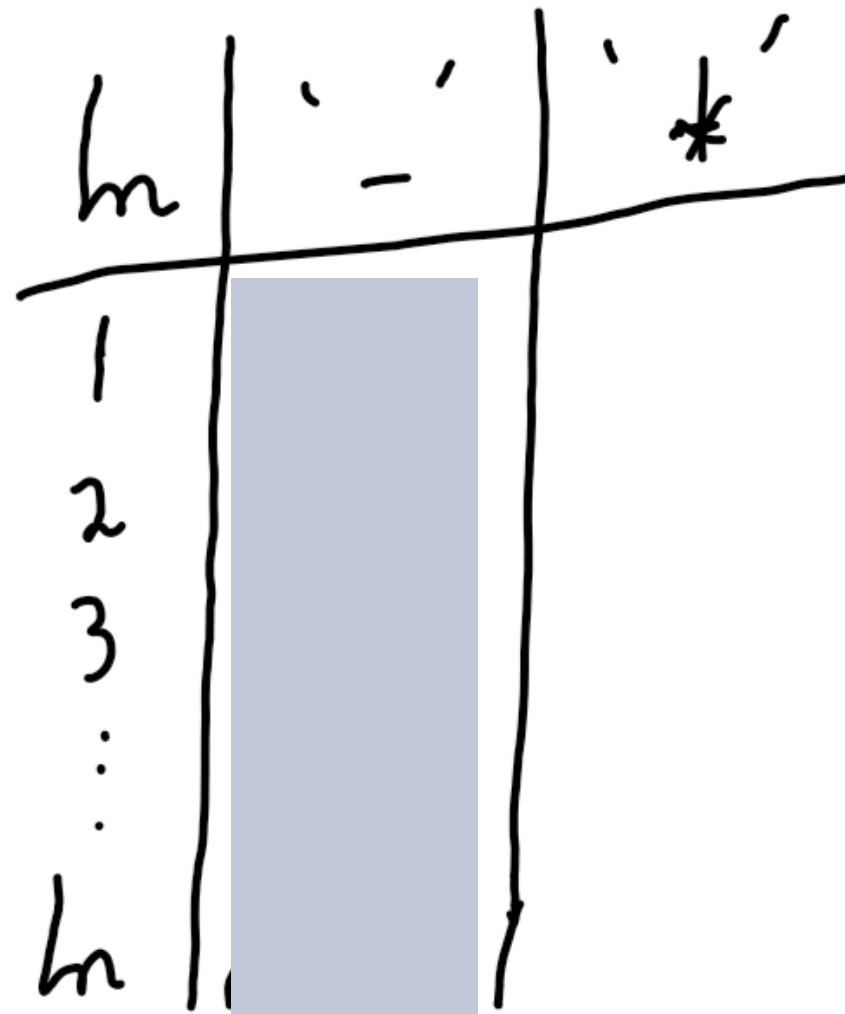
easily

H=5

```
-----*
----***
--*****
-*****
*****
```

H=6

```
-----*
----***
--*****
-*****
*****
*****
```



```
void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= [ ]; sp++)
            cout << " ";
        for (int st = 1; st <= [ ]; st++)
            cout << sym;
        cout << "\n";
    }
}
```

Pattern Printing

Undergrad Students process this very

easily

H=5

```

-----*
----****
---*****
--*****
-*****
*****

```

H=6

```

-----*
----****
---*****
--*****
-*****
*****

```

ln	'-'	'*'
1	H-1	
2	H-2	
3	H-3	
:	:	
.	.	
ln		

```

void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= [ ]; sp++)
            cout << "-";
        for (int st = 1; st <= [ ]; st++)
            cout << sym;
        cout << "\n";
    }
}

```

Pattern Printing

Undergrad Students process this very

easily

H=5

```

-----*
----****
---*****
--*****
-*****
*****

```

H=6

```

-----*
----****
---*****
--*****
-*****
*****

```

ln	' - '	' * '
1	H-1	
2	H-2	
3	H-3	
:	:	
:	.	
ln	H-ln	

```

void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= h - ln; sp++)
            cout << " ";
        for (int st = 1; st <= ; st++)
            cout << sym;
        cout << "\n";
    }
}

```

Pattern Printing

Undergrad Students process this very

easily

H=5

```

-----*
----***
---*****
--*****
-*****
*****

```

H=6

```

-----*
----***
---*****
--*****
-*****
*****

```

ln	' - '	' * '
1	H-1	
2	H-2	
3	H-3	
:	:	
:	:	
ln	H-ln	

```

void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= h - ln; sp++)
            cout << " ";
        for (int st = 1; st <= [REDACTED]; st++)
            cout << sym;
        cout << "\n";
    }
}

```


Pattern Printing

Undergrad Students process this very

easily

H=5

```

-----*
----****
---*****
--*****
-*****
*****

```

H=6

```

-----*
----****
---*****
--*****
-*****
*****

```

ln	-	*
1	H-1	1
2	H-2	3
3	H-3	5
:	:	:
ln	H-ln	

```

void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= h - ln; sp++)
            cout << "-";
        for (int st = 1; st <= ; st++)
            cout << sym;
        cout << "\n";
    }
}

```

Pattern Printing

Undergrad Students process this very

easily

H=5

```

-----*
----****
---*****
--*****
-*****
*****

```

H=6

```

-----*
----****
---*****
--*****
-*****
*****

```

ln	-	*
1	H-1	1
2	H-2	3
3	H-3	5
:	:	:
ln	H-ln	$2*ln-1$

```

void pyramid(int h, char sym='*')
{
    for (int ln = 1; ln <= h; ln++)
    {
        for (int sp = 1; sp <= h - ln; sp++)
            cout << "-";
        for (int st = 1; st <=  $2*ln-1$ ; st++)
            cout << sym;
        cout << "\n";
    }
}

```

Pattern Printing **High-School Students**

H=5

```
-----*
-----***
-----*****
-----*****
*****
```

H=6

```
-----*
-----***
-----*****
-----*****
-----*****
-----*****
*****
```

h \ - ' * '		
1	H-1	1
2	H-2	3
3	H-3	5
⋮	⋮	⋮
⋮	⋮	⋮

First, look at how the pattern is starting:

Pattern Printing **High-School Students**

H=5

```
-----*
-----***
-----*****
-----*****
-----*****
*****
```

H=6

```
-----*
-----***
-----*****
-----*****
-----*****
-----*****
-----*****
*****
```

h \ - *'		
1	H-1	1
2	H-2	3
3	H-3	5
⋮	⋮	⋮
⋮	⋮	⋮

First, look at how the pattern is starting:

- '-' is starting from **H-1**
- '*' is starting from **1**

Pattern Printing **High-School** **Students**

H=5

```
-----*
-----***
-----*****
-----*****
-----*****
*****
```

H=6

```
-----*
-----***
-----*****
-----*****
-----*****
-----*****
*****
```

H	-	*
1	H-1	1
2	H-2	3
3	H-3	5
⋮	⋮	⋮
⋮	⋮	⋮

First, look at how the pattern is starting:

- '-' is starting from **H-1**
- '*' is starting from **1**

Just look at the change now

Pattern Printing **High-School Students**

H=5

```
-----*
-----***
-----*****
-----*****
-----*****
*****
```

H=6

```
-----*
-----***
-----*****
-----*****
-----*****
-----*****
-----*****
*****
```

<i>ln</i>	<i>'-'</i>	<i>'*'</i>
1	H-1	1
2	H-2	3
3	H-3	5
:	:	:
.	.	.

First, look at how the pattern is starting:

- **'-'** is starting from **H-1**
- **'*'** is starting from **1**

Just look at the change now

- **'-'** is decrementing: by **-1**
- **'*'** is incrementing: by **+2**

Pattern Printing **High-School**

Students

H=5

```
-----*
----***
--*****
_*****
*****
```

H=6

```
-----*
----***
--*****
_*****
*****
```

h	-	*
1	H-1	1
2	H-2	3
3	H-3	5
:	:	:
.	.	.

```
void pyramid(int h) {
    int SP = h - 1;
    int ST = 1;

    for (int i = 1; i <= h; i++) {
        for (int j = 1; j <= SP; j++) {
            cout << " ";
        }
        for (int k = 1; k <= ST; k++) {
            cout << "*";
        }
        cout << endl;
        SP--;
        ST += 2;
    }
}
```

First, look at how the pattern is starting:

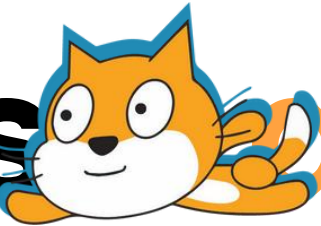
- '-' is starting from **H-1**
- '*' is starting from **1**

Just look at the change now

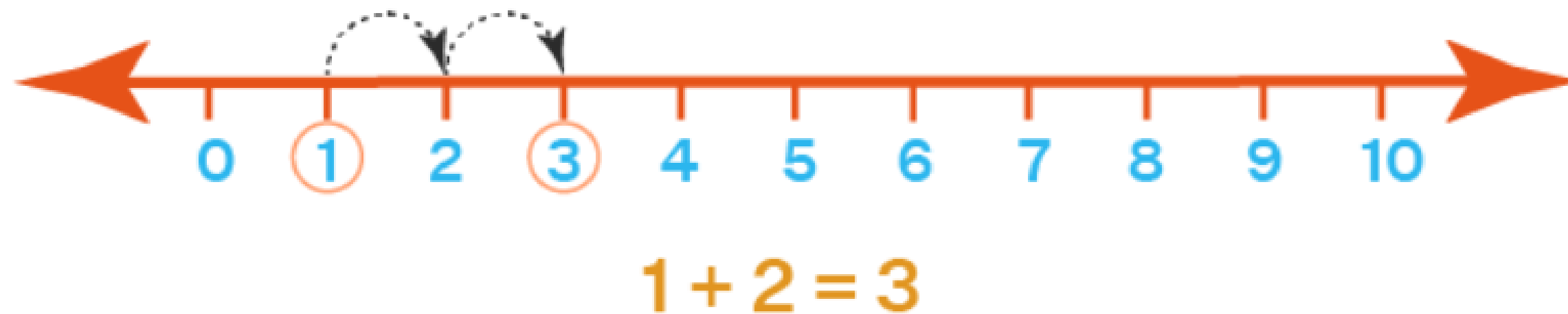
- '-' is decrementing: by **-1**
- '*' is incrementing: by **+2**

Primary School (K2-K5)

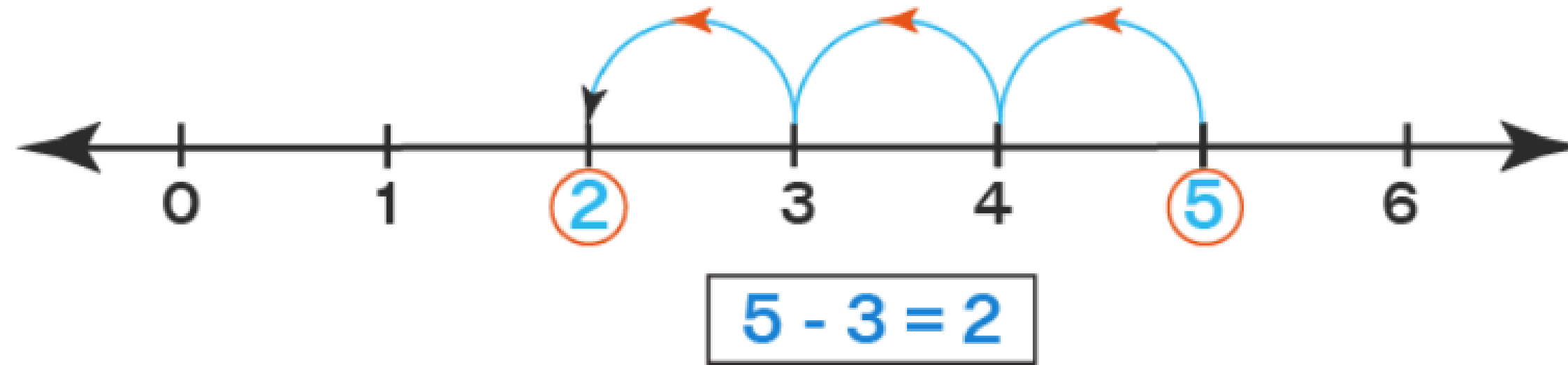
Student

Here comes  **daunting** but
beautiful **challenge**

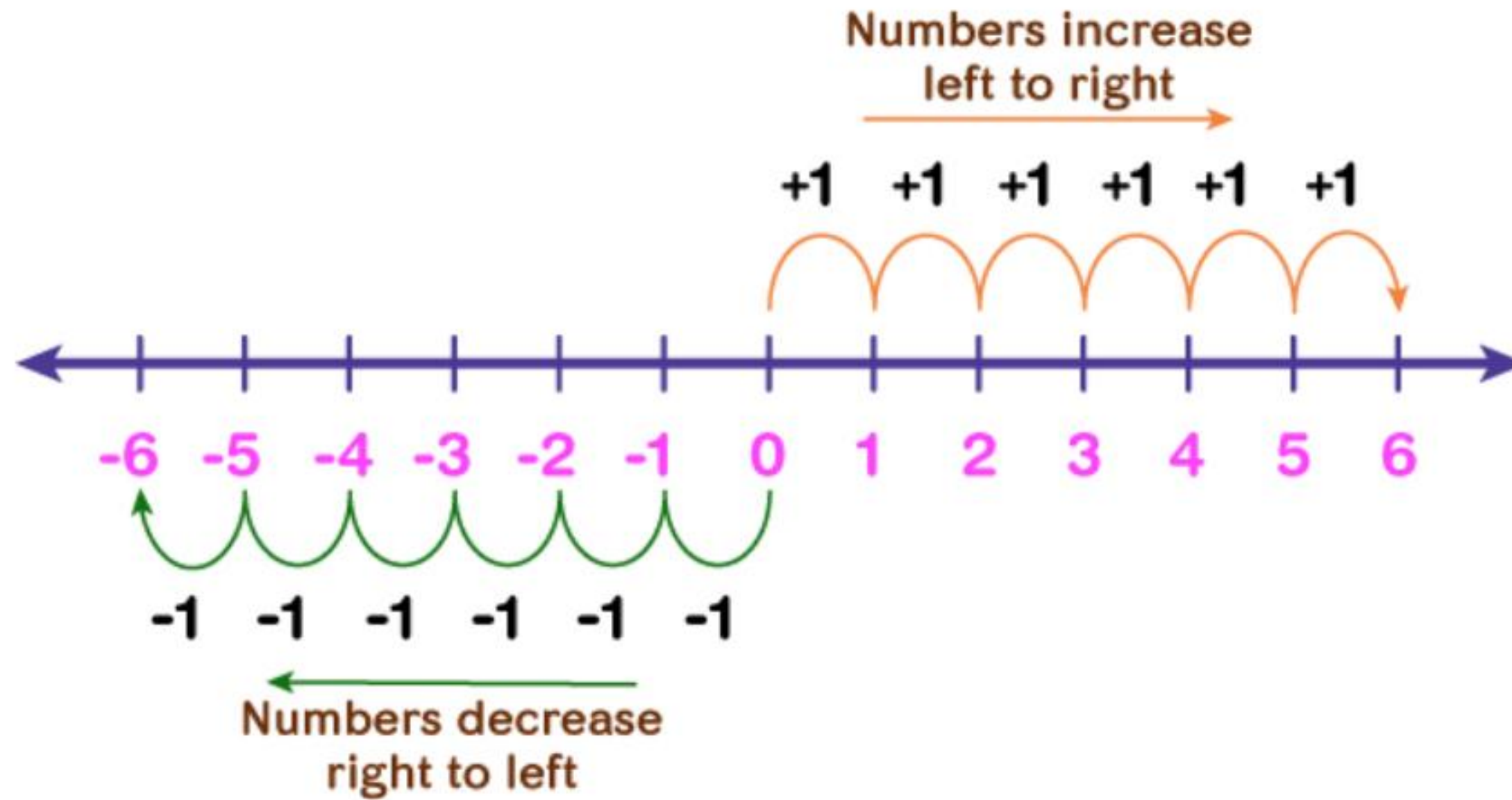
Number Line and **Addition**



Number Line and Subtraction

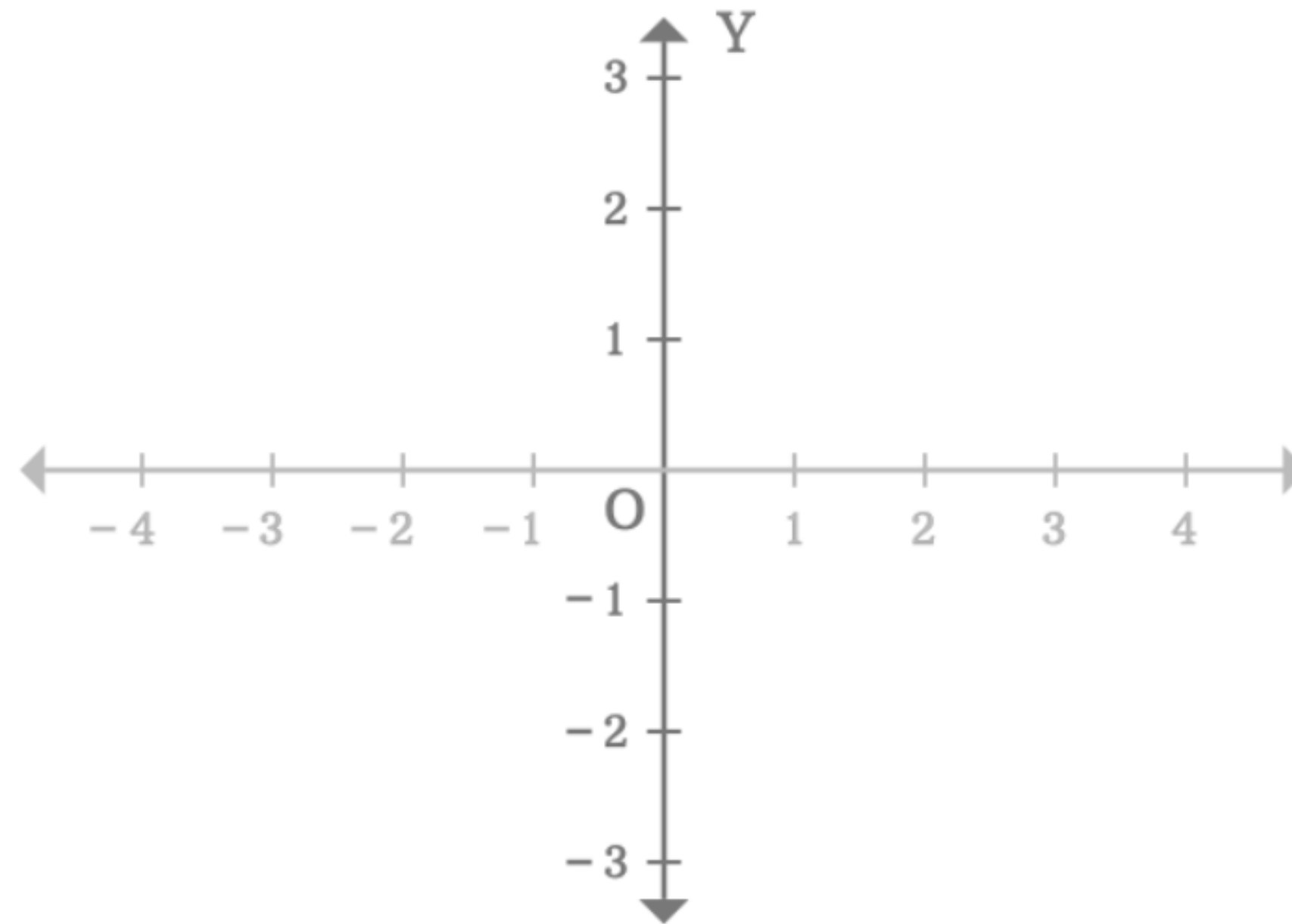


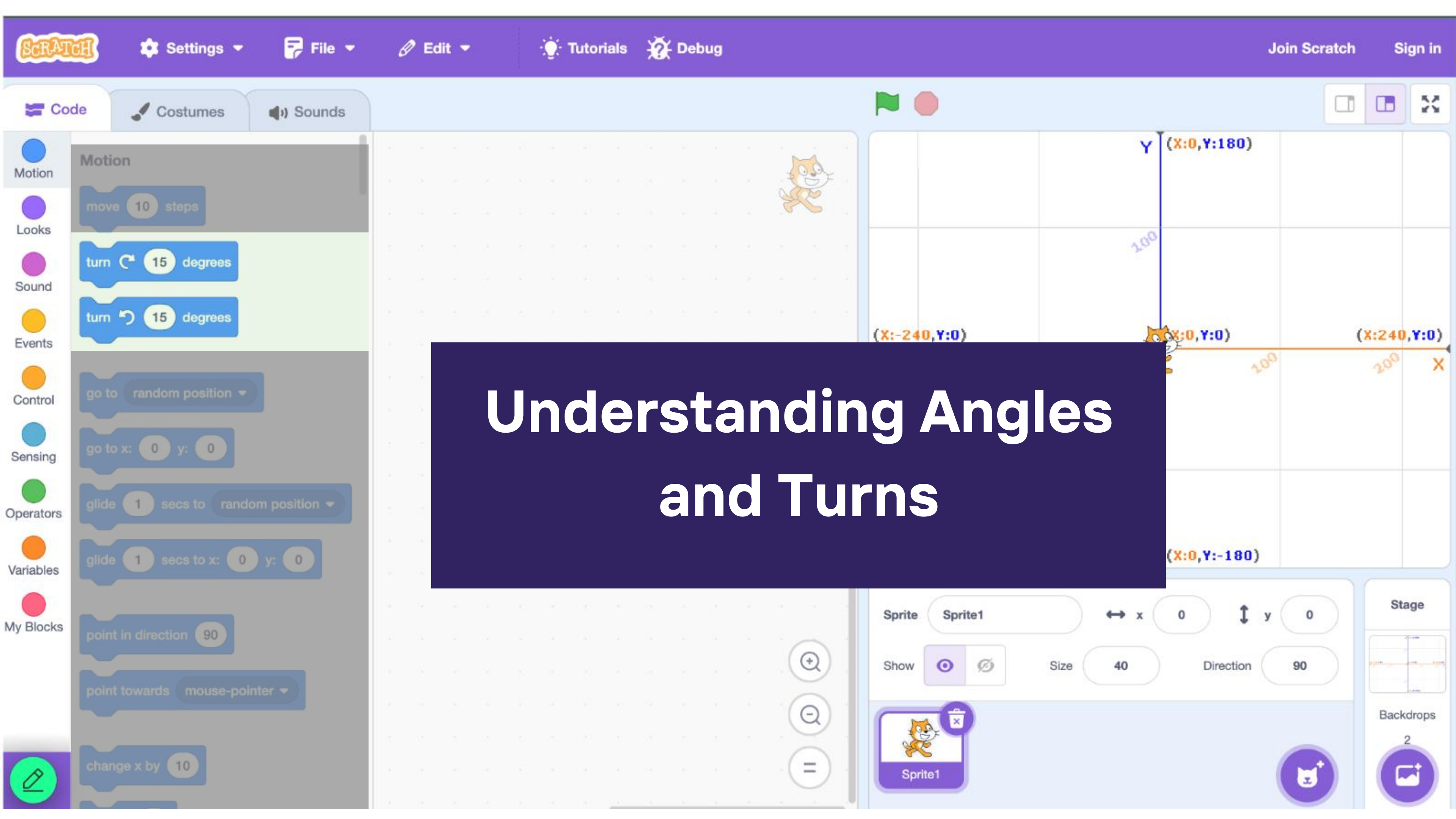
X - Axis (going beyond 0)



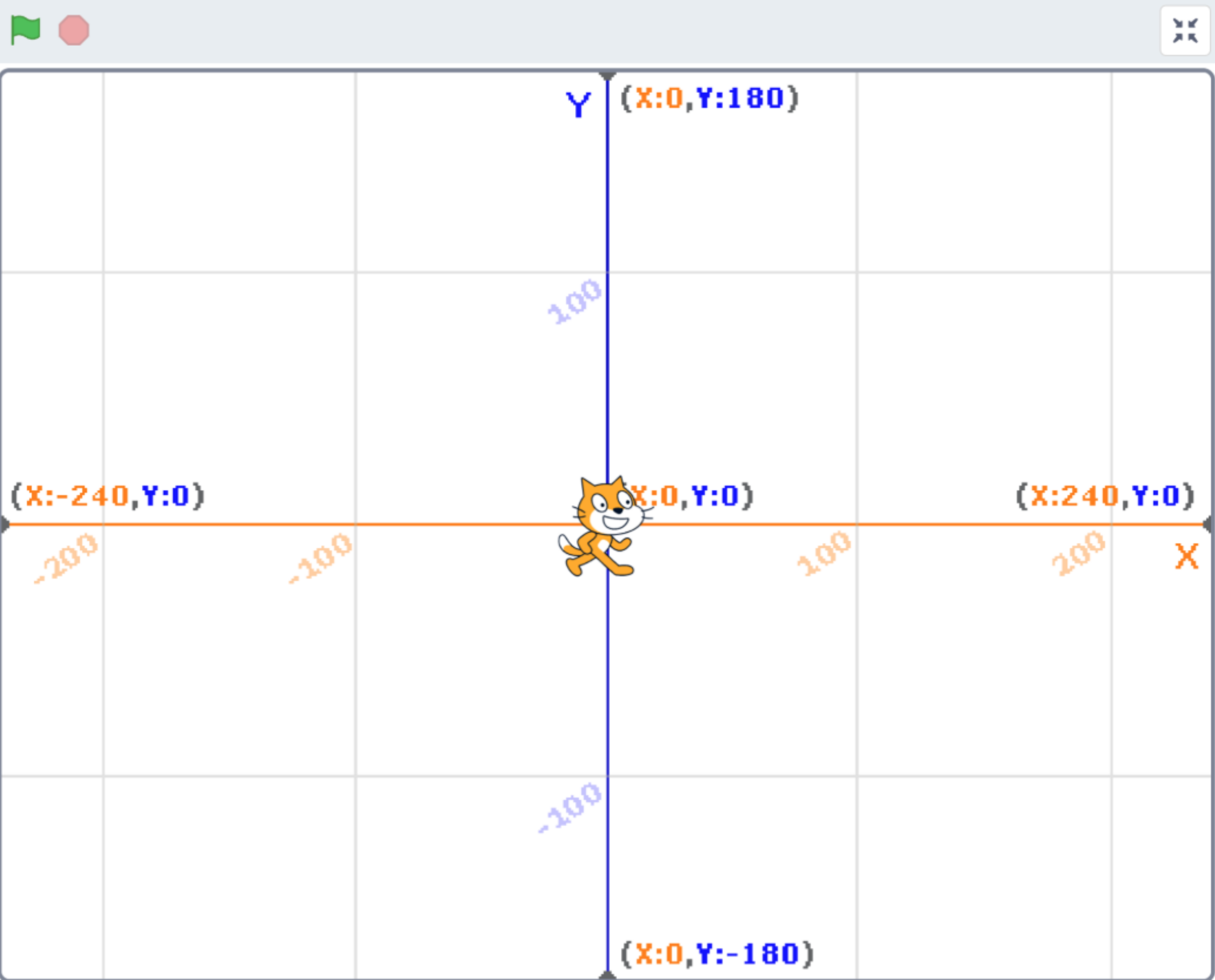
Number Line Increase Decrease

Introducing Y Axis (and seeing its +ve and -ve notions)

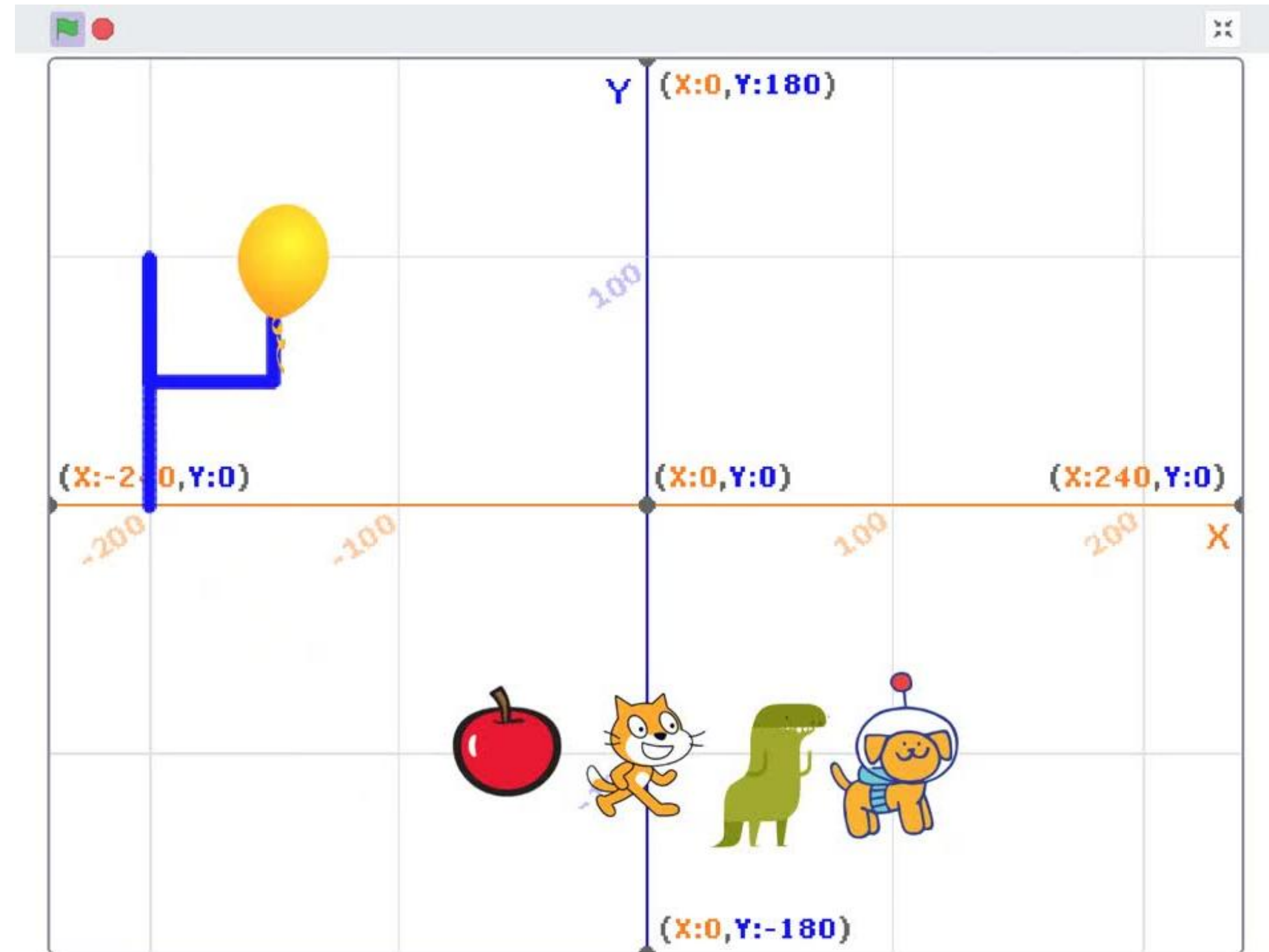


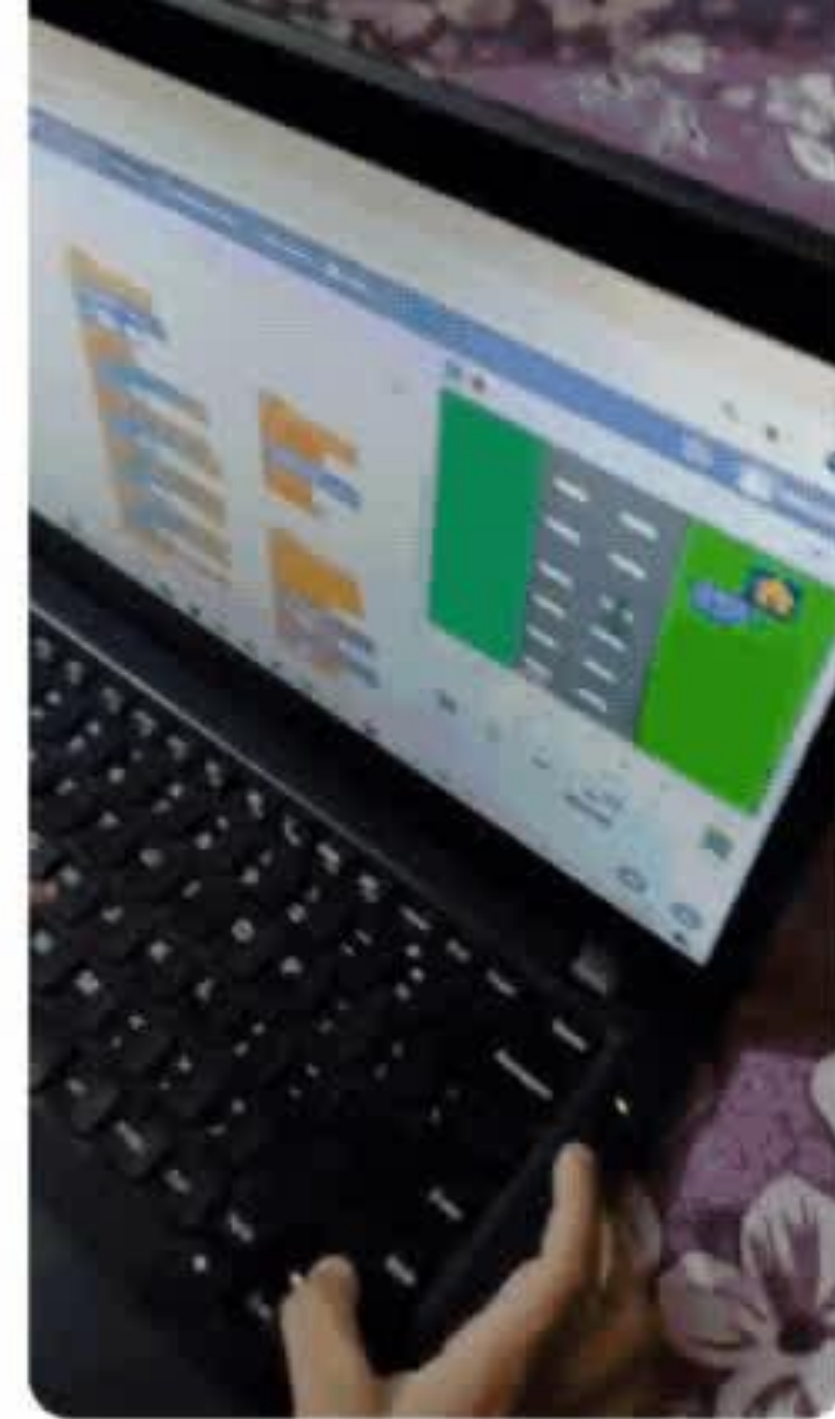
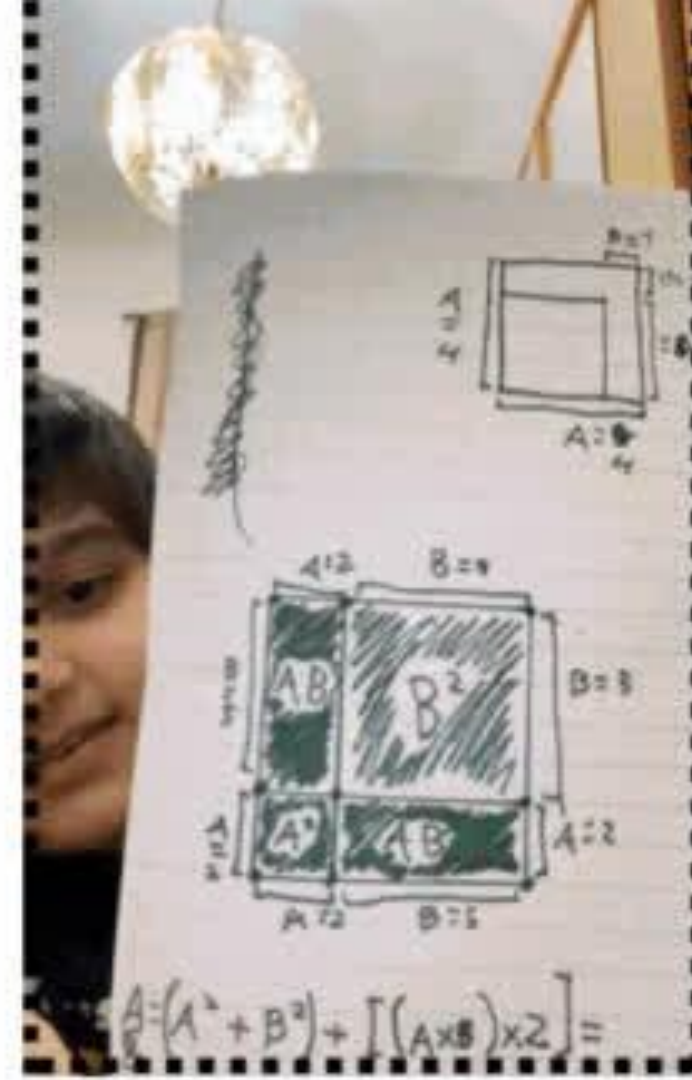


Understanding Angles and Turns

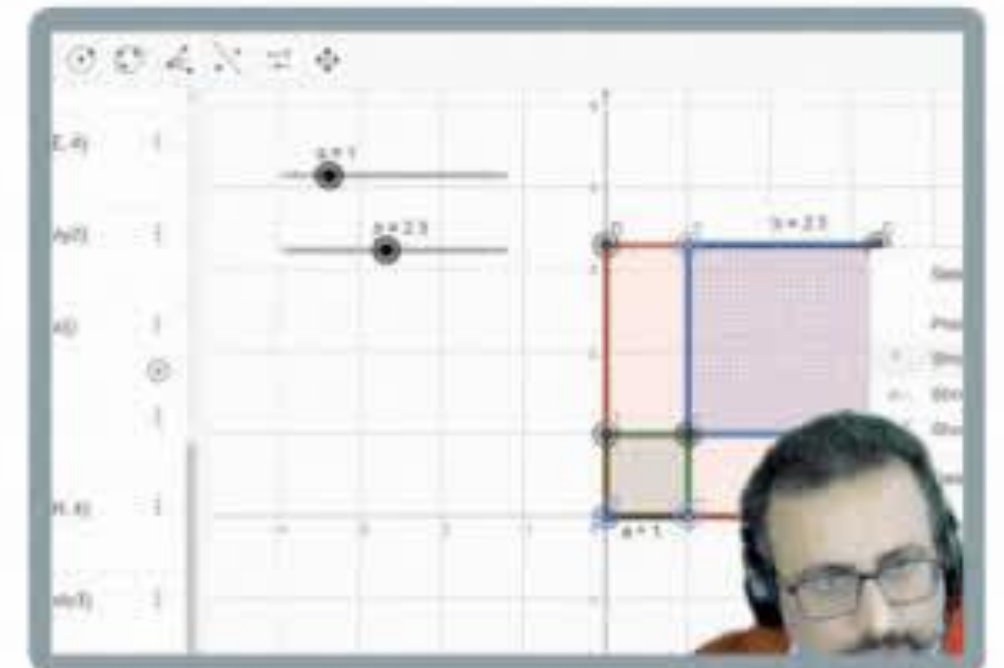


Turtle Graphics meets Algorithms

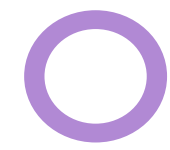




Some Memories



Good Practices for Teachers



Live Coding Demonstrations in the IDE

Good Practices for Teachers

Good Practices for Teachers



Live Coding Demonstrations in the IDE

⋮



Step-by-Step Dry Runs of Code

Good Practices for Teachers



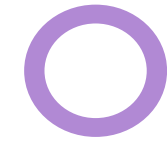
Live Coding Demonstrations in the IDE

⋮



Step-by-Step Dry Runs of Code

⋮



Practice Adding and Fixing Syntax Errors

Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- Step-by-Step Dry Runs of Code
- Practice Adding and Fixing Syntax Errors
- Encourage Participation from All Students

Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- ⋮
- Step-by-Step Dry Runs of Code
- ⋮
- Practice Adding and Fixing Syntax Errors
- ⋮
- Encourage Participation from All Students
- ⋮
- Highlight and Explain Compiler Errors

Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- ⋮
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- ⋮
- Practice Adding and Fixing Syntax Errors
- ⋮
- Encourage Participation from All Students
- ⋮
- Highlight and Explain Compiler Errors
- ⋮
- Ensure Code Visibility and Readable

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- Step-by-Step Dry Runs of Code
- Practice Adding and Fixing Syntax Errors
- Encourage Participation from All Students
- Highlight and Explain Compiler Errors
- Ensure Code Visibility and Readable
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Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- ⋮
- Step-by-Step Dry Runs of Code
- ⋮
- Practice Adding and Fixing Syntax Errors
- ⋮
- Encourage Participation from All Students
- ⋮
- Highlight and Explain Compiler Errors
- ⋮
- Ensure Code Visibility and Readable
- ⋮
- Discuss and Solve Unseen & Novel Problems
- ⋮
- Dedicate Office Time

Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- Step-by-Step Dry Runs of Code
- Practice Adding and Fixing Syntax Errors
- Encourage Participation from All Students
- Highlight and Explain Compiler Errors
- Ensure Code Visibility and Readable
- Discuss and Solve Unseen & Novel Problems
- Dedicate Office Time
- ChatGPT (Flip Classroom the only way forward)

Good Practices for Teachers

- Live Coding Demonstrations in the IDE
- ⋮
- Step-by-Step Dry Runs of Code
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- Practice Adding and Fixing Syntax Errors
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- ChatGPT (Flip Classroom the only way forward)

LLUMS

Thank You

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 www.seedprogramming.org

*Nourishing the **programmer** in you* 

