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Developing Algorithmic Thinking Using Crocheting Patterns as Educational Tool

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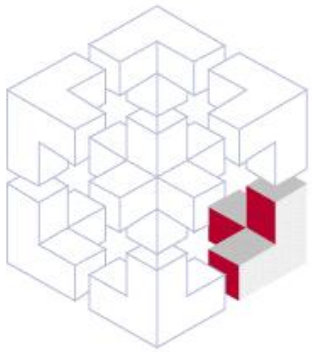


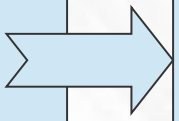
VISUALITY & MATHEMATICS
EXPERIENTIAL EDUCATION OF MATHEMATICS THROUGH

EU Competence – Mathematical Competence

“Mathematical competence is ability to develop and apply mathematical thinking in order to solve a range of problems in everyday situations, with the emphasis being placed on process, activity and knowledge.”

Polya's problem-solving principle

- Understand the Problem
- Devise a plan
- Carry out the Plan
- Look back



Identifying the problem

Understanding the problem

Representing the problem

Solving the problem

Communicating the results

Algorithmic Thinking

Special problem solving competence, which consists of several abilities (Futschek):

- Analyze given problem
- Specify problems precisely
- Find the basic action that are adequate to given problems

Algorithmic Thinking

- Construct correct algorithms to given problems using basic actions
- Think about all possible special and normal cases of a problem
- Evaluate algorithms
- Improve the efficiency of algorithms

Relationship Between Polya's Problem-Solving Principle and Algorithmic Thinking

- Analyze given problems ⟺ Identifying the problem
- Specify problem precisely ⟺ Understanding the problem and Representing the problem
- Construct correct algorithms to given problems using basic actions and Think about all possible special and normal cases of a problem ⟺ Solving the problem

Crocheting and Polya's Problem-Solving Principle

Polya’s strategies that could be used for solving problems

- guess and check
- make and orderly list
- eliminate possibilities
- use symmetry

Crocheting and Polya's Problem-Solving Principle

- consider special cases
- use direct reasoning
- solve an equation
- look for a pattern
- draw a picture

Crocheting and Polya's Problem-Solving Principle

- solve a simpler problem
- use a model
- work backward
- use a formula
- be ingenious

Crocheting and Polya's Problem-Solving Principle

we could start from patterns and build a model (look for a pattern, solve a simpler problem)

or

we can try to decompose into the pattern a model that is already made (use model, work backward)

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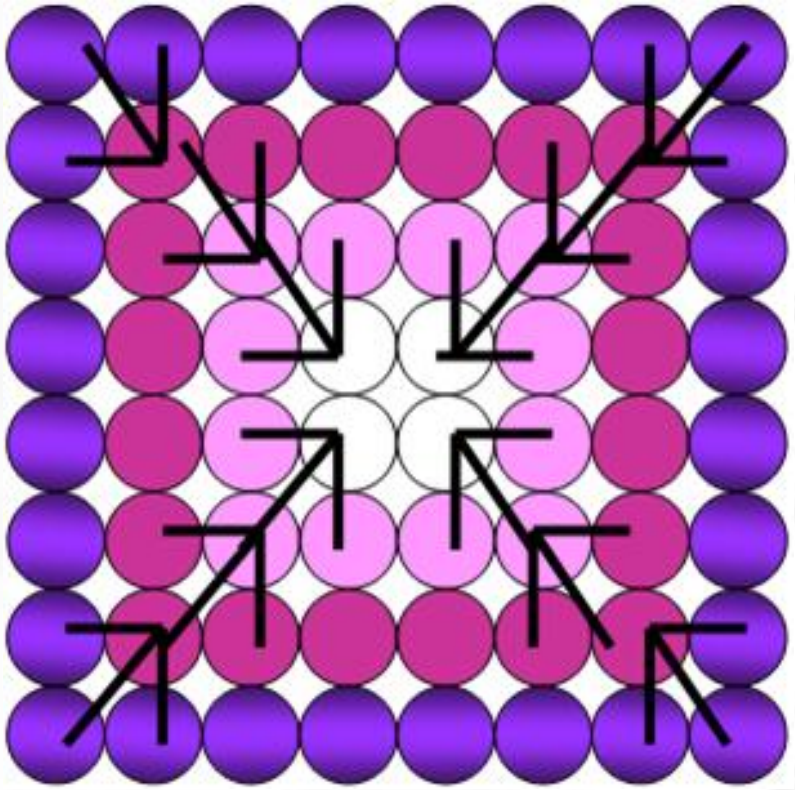
Crocheting and Polya's Problem-Solving Principle

In both cases we are drawing picture, using symmetry, considering all possible cases, using direct reasoning and finding a formula that describes the process of crocheting a model



Crocheting a Circle

Crocheting a Circle

- New measure: 1 mesh
- Perimeter of circle: P = 2*Pi*r
- 2*Pi = 2*3.14 = 6.28 ≈ 6 => Idea
- Idea = Arithemtical Progression

Crocheting a Circle
-Algorithm-

- **Step 0**: chain of 3 or 4meshes
- **Step 1**: build a circle using the chain from Step0
- **Step 2**: make a circle with 6 meshes (initial term of arithemtic progression)

Crocheting a Circle
-Algorithm-

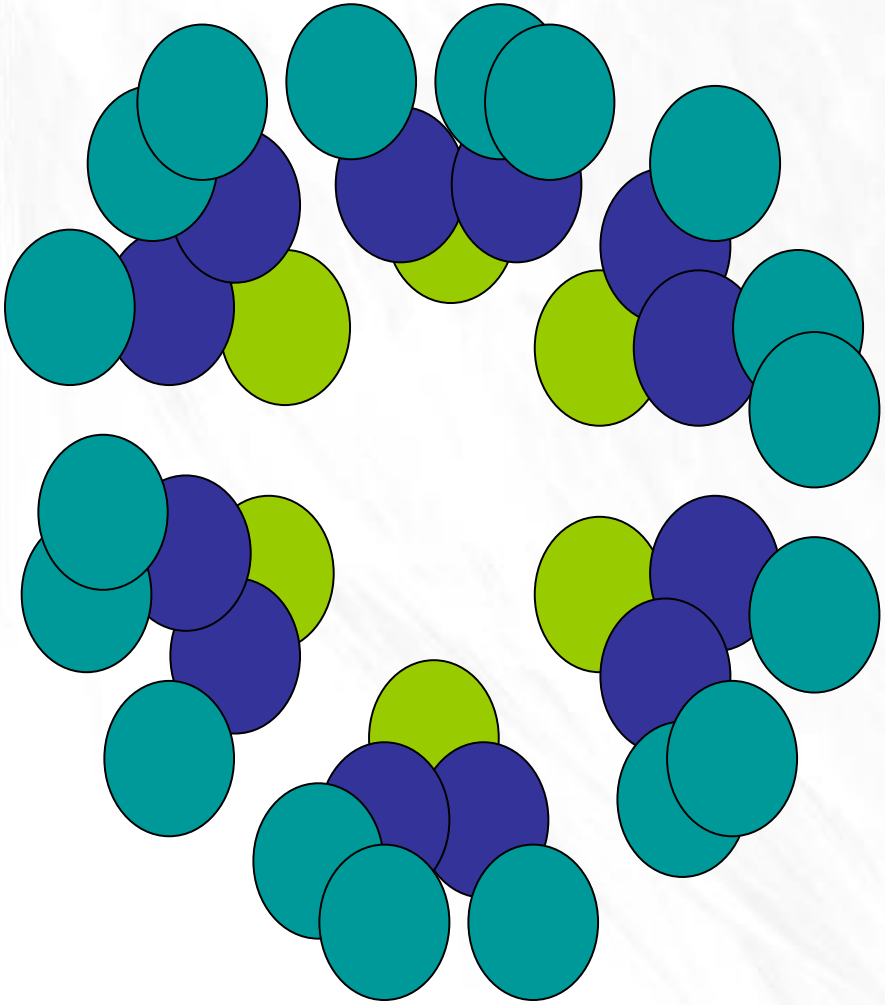
- Each next circle has 6 more meshes then previouse one => 6 = common difference of arithemtic progression

Crocheting a Circle
-Algorithm-

- **Step 3**: build a circle with 6 + 6 = 6+1*6 = 12 meshes, by using two meshes in every 6/6=1st mesh of a previous circle

- **Step 4**: build a circle with 6+12 = 6+2*6 = 18 meshes, by stitching two times in every 12/6=2nd mesh of a previous circle (and one stitch in all other meshes)

Crocheting a Circle
-Algorithm-



First circle with 6 meshes

Second circle with 12 meshes

Third circle with 18 meshes

Crocheting a circle
-Algorithm-

- **Step 5**: 6+18=6+3*6=24 meshes, by stitching two times in every 18/6=3rd mesh of a previous circle **6** (and one time in all other meshes)

- **Step N**: 6+(n-1)*6 meshes, by stitching two times in every [(n-1)*6]/6=(n-1)th mesh (and one time in all other meshes)

Crocheting a Circle
-General Solution-

- General solution => modifying algorithm

Crocheting a Circle
-General Solution-

- **Step 2**: build a circle with K meshes

- **Step 3**: IF K mod 6 == 0 THEN DO **Step 4** ELSE find the smallest number M that is bigger then K and that is M mod 6 == 0 AND make a circle with M meshes **(**M is initial term of arithmetic progression**)**

Crocheting a Square

Crocheting a Square
- starting point -

a=1

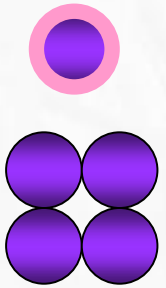
Crocheting a Square
- starting point -

a=1 there is 1 mash

Crocheting a Square
- starting point -

a=1 there is 1 mash

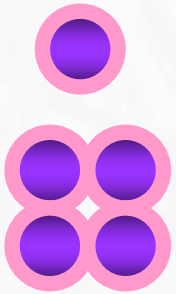
a=2



Crocheting a Square
- starting point -

a=1 there is 1 mash

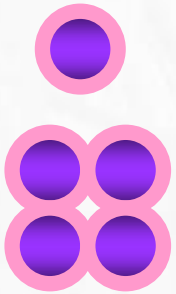
a=2 there are 4 mashes



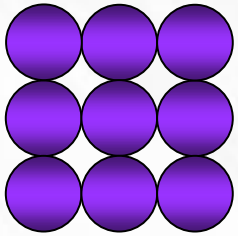
Crocheting a Square
- starting point -

a=1 there is 1 mash

a=2 there are 4 mashes



a=3

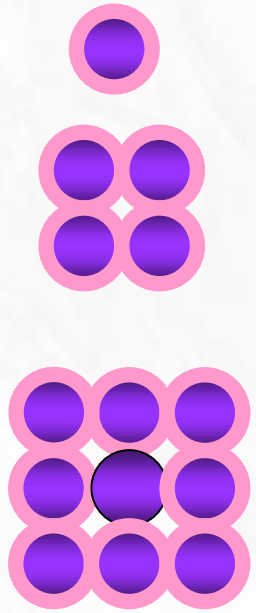


Crocheting a Square
- starting point -

a=1 there is 1 mash

a=2 there are 4 mashes

a=3 there are 8 mashes



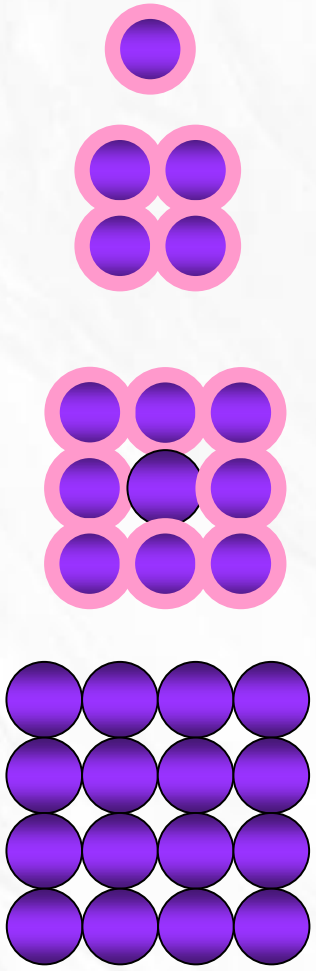
Crocheting a Square
- starting point -

a=1 there is 1 mash

a=2 there are 4 mashes

a=3 there are 8 mashes

a=4



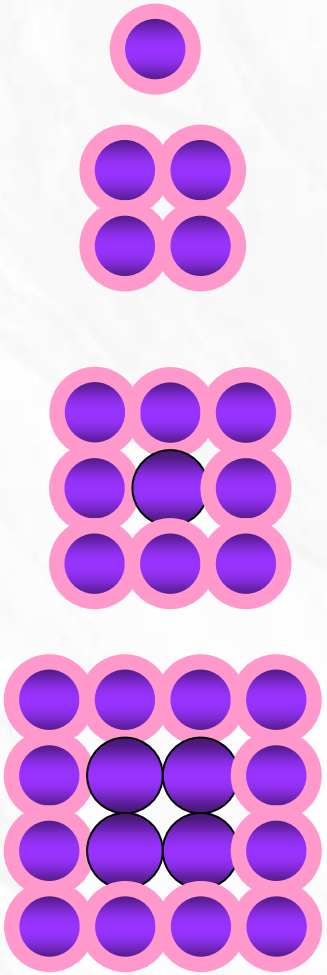
Crocheting a Square
- starting point -

a=1 there is 1 mash

a=2 there are 4 mashes

a=3 there are 8 mashes

a=4 there are 12 mashes



Crocheting a Square
- starting point -

a=n there are 4x(n-1) mashes

in each new square, we need to have 4 new mashes

Crocheting a Square
- starting point -

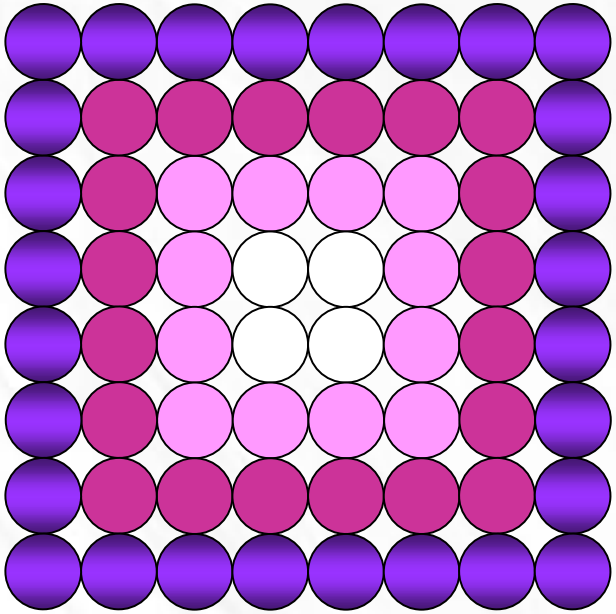
can we make an algorithm?

of corse

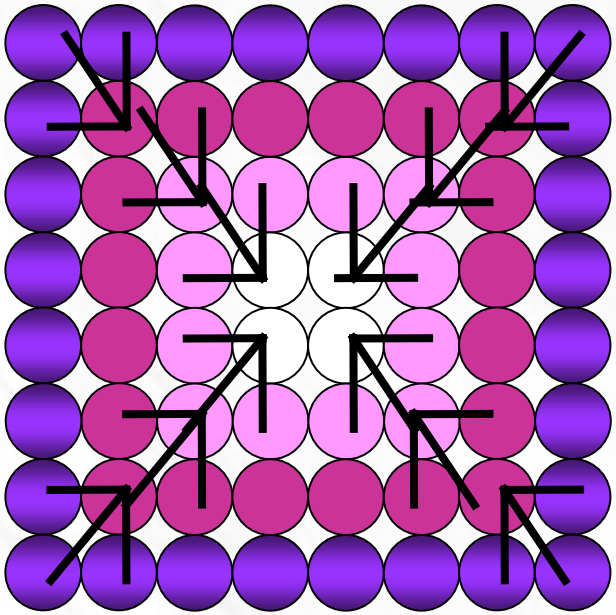
will it be right?

Crocheting a Square
- starting point -

?



Crocheting a Square
- starting point -



Crocheting a Square
- algorithm -

- **Step 0**: chain of 2 or 3 mashes
- **Step 1**: make a circle using the chain from a Step 0
- **Step 2**: make a square with a = 2, with 4 mashes (initial term of arithemtic progression)

Crocheting a Square
- algorithm -

each next square has 8 more mashes then previouse one =>

8 = common difference of arithemtic progression

Crocheting a Square
- algorithm -

- **Step 3**: make a square with a = 3, with 4 + 4 = 8 mashes, by making 3 mashes in every $4/4=1^{st}$ mash of a previous circle
- **Step 4**: make a square with a = 4, with 8 + 4 = 12 mashes, by making 3 mashes in every $8/4=2^{st}$ mash of a previous circle
- **Step n:** make a square with a = n, 4x(n – 1) by making 3 mashes in every $4x(n-2)/4=(n-2)^{st}$ mash of a previous circle

Crocheting a Square

Crocheting as a slide rule

Why crocheting

theoretical and abstract approach is still more valued

scientist are thinking mostly about contribution to scientific world and less how to contribute to society or development of education

althgough crocheting algorithms are not higher mathematics, it is not just funny way of learning things

both experimantal and tactile approach is giving not different point of view, but rather more acceptable way of gaining knowledge about the geometry and mathematical concepts

Conclusion

In our own experience, students should work on:

- making a clear idea of a model
- visualisation of a model
- calculation of some function (in our example perimeter for a sequence of circles/squares)
- ability to make a drawing of a model

Conclusion

- skill of crocheting, so she/he could make experiments
- think and rethink, going back, if experiment fail
- make an algorithm, i.e. put a solution in a reusable form, from beginning to the end

Conclusion

students are encouraged to develop their mental processes which will lead them to succeed in problem solving

this sort of teaching is usable for students with different cognitive learning styles - visual, auditory, and kinaesthetic/ tactile

Thank you!