The crop circles – an inspiration for project-based learning in a Logo environment

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Abstract

This paper presents a specific project (*Modelling the crop circles*) developed by the authors in the frames of a teacher training course on Logo and ICT. Because of the variety of crop circles being documented it is possible to formulate a rich set of problems addressing the development of both mathematics and informatics skills. During the course, together with mastering the Logo language, the authors experienced such important skills as team work, distributing the tasks, planning ahead, searching and selecting the relevant information and sharing the final product with an audience (all of these ICT-enhanced skills being crucial components of the constructionism). As part of the project they offered ideas for encouraging junior high-school students to look for Logo realisations of the crop models which could be qualified as "the best" according to different criteria – closeness to the original, readability, potential for generalizations, etc.

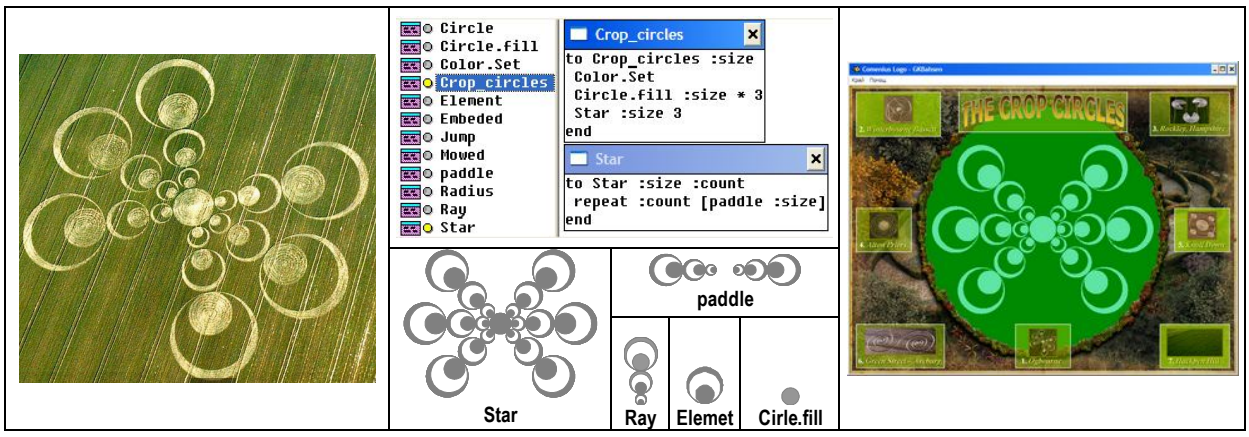


Figure 1. Modelling a specific crop circle configuration by means of Comenius Logo

As an example, the modelling of a specific crop circle configuration is considered together with the mathematics and informatics knowledge needed (Figure 1). The configuration itself represents a building block of a bigger project (a set of crop circle configurations chosen by a team of students).

Keywords

Project-based learning, ICT-enhanced skills, crop circles, mathematics, informatics.

Introduction

The idea of the project presented in this paper was born in the frames of the course *Programming languages and environments in education* (lead by Jenny Sendova) meant for in-service teachers in mathematics who would like to teach in addition informatics and information technologies. The participants are expected to prepare and defend a project that could be used as a model for project-based learning. One of the challenges the IT teachers-to-be are facing is to find motivating themes that correspond to the various interests of the students and could stimulate their research potential. New pedagogic strategies and approaches (such as the team work, project-based work, the teachers acting as partners in the learning process) have also been implemented in this course (Stefanova et al, 2007). In search of objects which could be easily modeled by means of Logo and at the same time provoking the interest of a larger audience we came across the crop circles.

The project design

The background

The crop circles are sizeable patterns created by the mysterious flattening of crops. These patterns appear in one night and usually there are no footmarks left around them.

The earliest recorded image resembling a crop circle is depicted in an English woodcut pamphlet published in 1678 called the "Mowing-Devil". The image depicts a demon with a scythe mowing an oval design in a field of oats. The pamphlet's text reads as follows:

> *Being a true relation of a farmer, who bargaining with a poor mower, about the cutting down three half acres of oats, upon the mower's asking too much, the farmer swore that the devil should mow it, rather than he* (http://www.rense.com/general39/mow.htm).

There are various theories about the origin of the crop circles. For the UFO supporters, the circles are signatures left behind by visiting spaceships. For mother-earth mystics, they're the manifestations of deep waves of natural energy. For psychics, they're the conscious results of remote-viewing experiments. For fringe physicists, they're the tracks of ionized plasma whirlwinds. But the most likely is that the pranksters or circlemakers are human that take fun in building such weird circles. As yet no conclusive evidence has been found for any of these theories (http://aliens.monstrous.com/crop_circles.htm).

Pictures of crop circles are presented in Figures 2-7 (http://www.lucypringle.co.uk/).

Figure 2. Ogbourne

Figure 3. Winterbourne Bassett

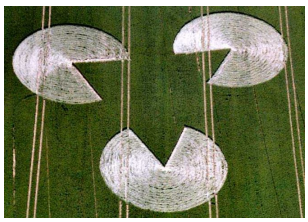


Figure 4. Rockley

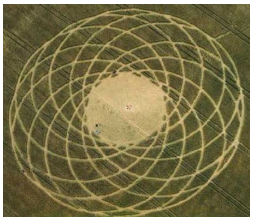


Figure 5. Alton Priors

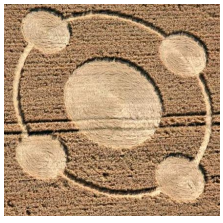


Figure 6. Knoll Down

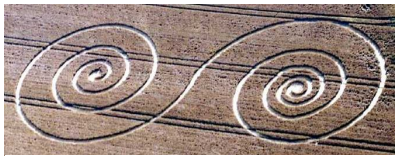


Figure 7. Hackpen Hill

The whole mystery around the crop circles theme appears to be very intriguing for students with various interests and it grabs easily their attention. Furthermore the great number of publications on this theme and the variety of crop circles being documented could be used as a base for the formulation of a rich set of problems addressing the development of both mathematics and informatics skills.

Figure 8. Logo models of the crop-circle configurations in Figures 2-7

To illustrate this idea we are going to present the process of modeling specific crop circle configurations (Figure 8).by means of Comenius Logo (Blaho and Kalas, 1998).

Harnessing mathematics and informatics tools

Let us consider now the modeling of the *Ogbourne* crop circle (Figure 2). This is a motive, which could be generated by means of geometric transformations (dilation, rotation and symmetry). The figure  could be considered as a building element which should undergo dilation (with ratio 2 and 3), then translation, symmetry, and finally - rotation. This makes it natural to create first a procedure for drawing a circle with a parameter for the radius, and then – a procedure for

the building element  , again with a parameter for the radius of the smallest circle. The first challenge for the students from mathematics point of view is to decide how to create a procedure for a circle (Sendova, Ivanov and Nikolov, 2002). If they decide to approximate it by a 360-gon with a parameter for the side length they might use the following procedures:

```
to Circle :s
    repeat 360 [fd :s rt 1]
end
```

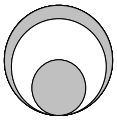
```
to Circle :s :b
   if :b=0 [Stop]
   fd :s rt 1 Circle :s :b-1
end
```

This definition reflects better the intuitive movement along a circle. We fill it with color to imitate the real process of the crop of oats being mowed. It could be generated:

```
to Circle.Fill :s
    Let “x Xcor Let “x Ycor
    pu lt 90 fd Radius :s rt 90 pd
    Circle :s pu SetXY :x :x pd fill
end
```

```
to Radius :s
    op (180*:s)/3.14
end
```

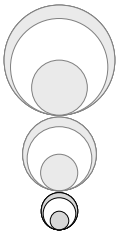
To move to the next circle so as to generate  it is not very natural to go along half of the circle instead of the diameter. Thus the next version of a circle procedure would be with the radius as a parameter.



```
to Element :s
    Let "LR ( list :s 1.75*:s 2*:s )
    Embeded :LR
    Mowed :R ;
    end
```

```
to Embeded :LR
   if empty? :LR [stop]
   Circle first :LR
   Embeded bf :LR
end
```

```
to Mowed :R
 Let "x Xcor Let "y Ycor rt 90
 pu fd :R pd fill
 pu fd :R * 2.75 fill
 SetXY :x :y pd
end
```



The procedure for this element is as follows:

```
to Ray :s
    Let "b 1 Radius :s
    repeat 3 [Let “v :s*:b Element :v
          pu fd Jump :v 4 pd lt 90 Let "b :b+1]
   pu
end
```

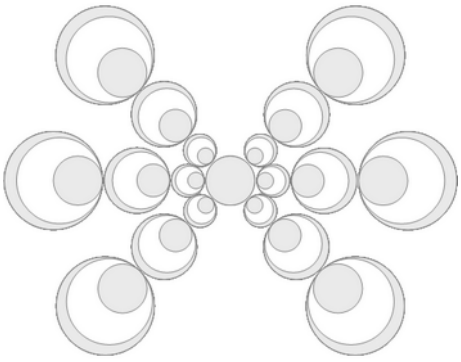
```
to Jump :s :b
    Let “r Radius :s
    op :r*:b+(:R/8)
end
```

Then we reflect it:

The procedure for this element is as follows:

```
to paddle :s
    Let "x Xcor Let "y Ycor rt 45
    repeat 2 [pu fd Jump :s 3 pd lt 90 Ray :s SetXY :x :y lt 90]
end
```

Finally we rotate3 times it in 45 degrees to get the following:



The procedure for this element is as follows:

```
to Crop_circles :size
    Color.seting
    Circle.fill :size*3
    Star :size 3
end
```

```
to Star :size :counter
    repeat :counter [paddle :size]
end
```

```
to Color.seting
    setpc [95 230 164]
    setbg [0 140 0]
end
```

Various mathematical ideas could be explored in this context – there is more than one definition of the same notion, the computer circle is just an approximation of the mathematical notion of *circle* but could be close enough for practical goals. The final composition could be achieved by combining several geometric transformations and there is a variety of ways of doing this.

Similarly, we modeled the rest of the crop-circle configurations (See the Appendix for the code).

The final presentation

After finishing the Logo code, the next step in the project was to create a professional presentation. For the purpose we used the *Prezi* presentation tool (http://prezi.com/6qjnuyxuubkg/) in which it was easy to present dynamically the original pictures of the crop circles together with a documentary, their computer models, and the corresponding Logo code.

What was learned?

The project is very rich both from mathematics and informatics point of view. The following questions arose during its development: What programming style to choose – bottom-up, top down, or a combination of both? How many procedures and parameters to use, e.g. is it natural to represent the circle as a partial case of an arc and make a procedure for arc only? To use or not to use recursion? And if we decide to use recursion how to determine the best possible way to do this? To use an inbuilt procedure for a polygon filled with color? The next questions are related to when to stop – shall we just create a good enough approximation of the model on the picture, or rather create a whole class of similar figures (with an arbitrary number of circles, branches of circles, other polygons, etc.) The more sophisticated informatics tools the students learn the more elegant and simple their procedures will be.

Ideas for further development

As far as the future development of the project is concerned it could embrace modeling of more crop-circle configurations that have been documented, or extend and generalize the existing models in specific manners. In any case, the students would feel as real researchers who try to understand the nature of this phenomenon, to express their opinion on the existing hypotheses based on their personal modeling experience.

The most important for the children is to use research approaches in a logical order so a to get a final product that could be presented and shared – something crucial for the ideas of the constructionism (Papert, 1999)

Acknowledgments

We would like to express our gratitude to Jenny Sendova for sharing her love for Logo as a language, educational philosophy and culture with us.

References

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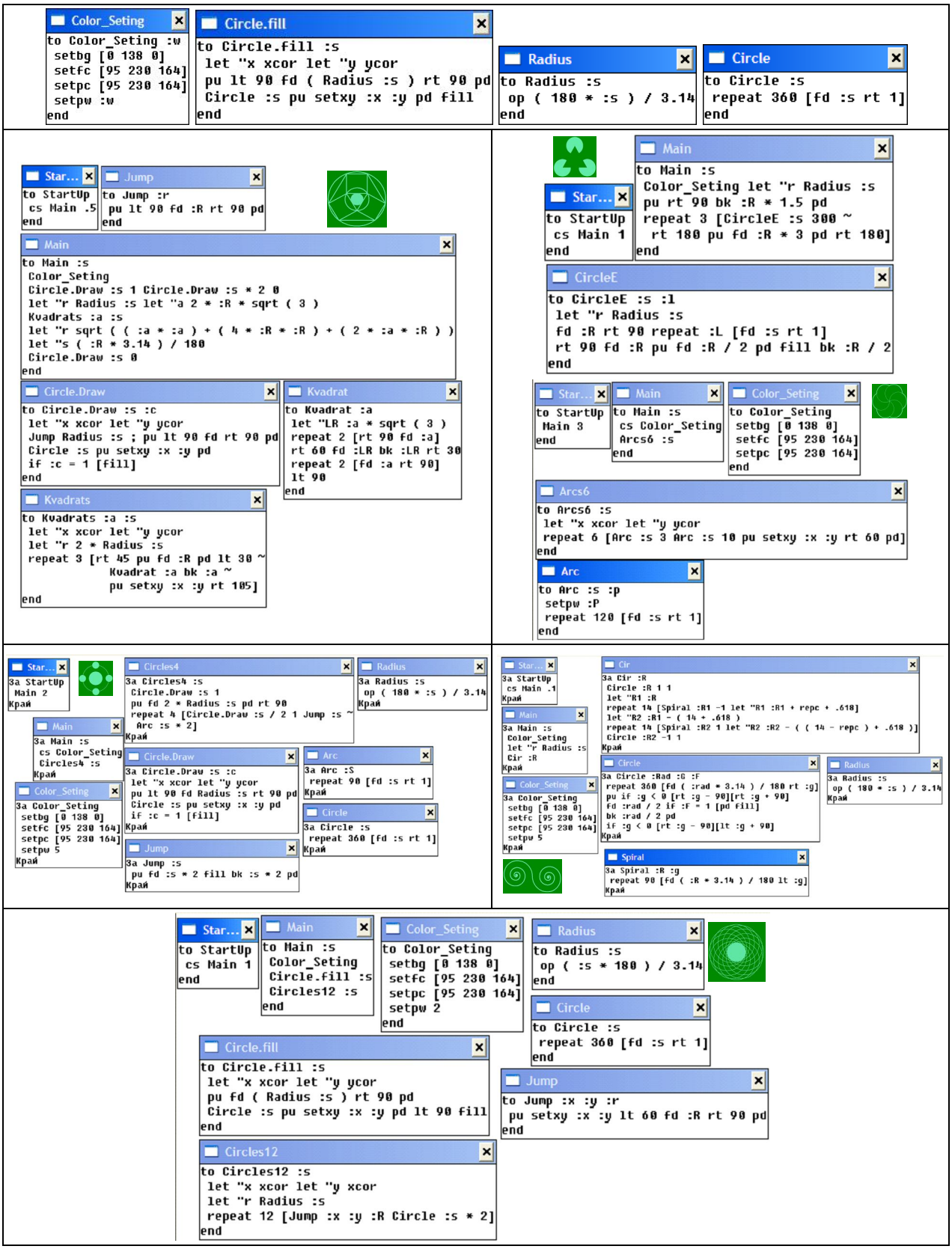
Appendix


Color_Seting
to Color_Seting :w
setbg [0 138 0]
setfc [95 230 164]
setpc [95 230 164]
setpw :w
end
Circle.fill
to Circle.fill :s
let "x xcor let "y ycor
pu lt 90 fd (Radius :s) rt 90 pd
Circle :s pu setxy :x :y pd fill
end
Radius
to Radius :s
op (180 * :s) / 3.14
end
Circle
to Circle :s
repeat 360 [fd :s rt 1]
end
Star...
to StartUp
cs Main .5
end
Jump
to Jump :r
pu lt 90 fd :R rt 90 pd
end
Main
to Main :s
Color_Seting
Circle.Draw :s 1 Circle.Draw :s * 2 0
let "r Radius :s let "a 2 * :R * sqrt (3)
Kvadrats :a :s
let "r sqrt ((:a * :a) + (4 * :R * :R) + (2 * :a * :R))
let "s (:R * 3.14) / 180
Circle.Draw :s 0
end
Circle.Draw
to Circle.Draw :s :c
let "x xcor let "y ycor
Jump Radius :s ; pu lt 90 fd rt 90 pd
Circle :s pu setxy :x :y pd
if :c = 1 [fill]
end
Kvadrat
to Kvadrat :a
let "LR :a * sqrt (3)
repeat 2 [rt 90 fd :a]
rt 60 fd :LR bk :LR rt 30
repeat 2 [fd :a rt 90]
lt 90
end
Kvadrats
to Kvadrats :a :s
let "x xcor let "y ycor
let "r 2 * Radius :s
repeat 3 [rt 45 pu fd :R pd lt 30 ~
Kvadrat :a bk :a ~
pu setxy :x :y rt 105]
end
Main
to Main :s
Color_Seting let "r Radius :s
pu rt 90 bk :R * 1.5 pd
repeat 3 [CircleE :s 300 ~
rt 180 pu fd :R * 3 pd rt 180]
end
Star...
to StartUp
cs Main 1
end
CircleE
to CircleE :s :l
let "r Radius :s
fd :R rt 90 repeat :L [fd :s rt 1]
rt 90 fd :R pu fd :R / 2 pd fill bk :R / 2
end
Star...
to StartUp
Main 3
end
Main
to Main :s
cs Color_Seting
Arcs6 :s
end
Color_Seting
to Color_Seting
setbg [0 138 0]
setfc [95 230 164]
setpc [95 230 164]
end
Arcs6
to Arcs6 :s
let "x xcor let "y ycor
repeat 6 [Arc :s 3 Arc :s 10 pu setxy :x :y rt 60 pd]
end
Arc
to Arc :s :p
setpw :P
repeat 120 [fd :s rt 1]
end
Star...
3a StartUp
Main 2
Край
Circles4
3a Circles4 :s
Circle.Draw :s 1
pu fd 2 * Radius :s pd rt 90
repeat 4 [Circle.Draw :s / 2 1 Jump :s ~
Arc :s * 2]
Край
Radius
3a Radius :s
op (180 * :s) / 3.14
Край
Main
3a Main :s
cs Color_Seting
Circles4 :s
Край
Circle.Draw
3a Circle.Draw :s :c
let "x xcor let "y ycor
pu lt 90 fd Radius :s rt 90 pd
Circle :s pu setxy :x :y pd
if :c = 1 [fill]
Край
Arc
3a Arc :S
repeat 90 [fd :s rt 1]
Край
Color_Seting
3a Color_Seting
setbg [0 138 0]
setfc [95 230 164]
setpc [95 230 164]
setpw 5
Край
Circle
3a Circle :s
repeat 360 [fd :s rt 1]
Край
Jump
3a Jump :s
pu fd :s * 2 fill bk :s * 2 pd
Край
Star...
3a StartUp
cs Main .1
Край
Cir
3a Cir :R
Circle :R 1 1
let "R1 :R
repeat 14 [Spiral :R1 -1 let "R1 :R1 + repc + .618]
let "R2 :R1 - (14 + .618)
repeat 14 [Spiral :R2 1 let "R2 :R2 - ((14 - repc) + .618)]
Circle :R2 -1 1
Край
Main
3a Main :s
Color_Seting
let "r Radius :s
Cir :R
Край
Color_Seting
3a Color_Seting
setbg [0 138 0]
setfc [95 230 164]
setpc [95 230 164]
setpw 5
Край
Circle
3a Circle :Rad :0 :F
repeat 360 [fd (:rad * 3.14) / 180 rt :g]
pu if :g < 0 [rt :g - 90][rt :g + 90]
fd :rad / 2 if :F = 1 [pd fill]
bk :rad / 2 pd
if :g < 0 [rt :g - 90][lt :g + 90]
Край
Radius
3a Radius :s
op (180 * :s) / 3.14
Край
Spiral
3a Spiral :R :g
repeat 90 [fd (:R * 3.14) / 180 lt :g]
Край
Star...
to StartUp
cs Main 1
end
Main
to Main :s
Color_Seting
Circle.fill :s
Circles12 :s
end
Color_Seting
to Color_Seting
setbg [0 138 0]
setfc [95 230 164]
setpc [95 230 164]
setpw 2
end
Radius
to Radius :s
op (:s * 180) / 3.14
end
Circle
to Circle :s
repeat 360 [fd :s rt 1]
end
Circle.fill
to Circle.fill :s
let "x xcor let "y ycor
pu fd (Radius :s) rt 90 pd
Circle :s pu setxy :x :y pd lt 90 fill
end
Jump
to Jump :x :y :r
pu setxy :x :y lt 60 fd :R rt 90 pd
end
Circles12
to Circles12 :s
let "x xcor let "y xcor
let "r Radius :s
repeat 12 [Jump :x :y :R Circle :s * 2]
end