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NATIONAL REPORTS - SLOVENIA

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INTRODUCTION

The report describes the validation phase of testing the C4G approach in Slovenia, presents the evaluation tools used and the results obtained by students, teachers and external experts.

The method of test implementation and data collection is described. The results were obtained in the one-week winter school, one course and two workshops.

The analysis is quantitative and qualitative and shows the suitability of the developed C4G approach for learning programming through designing games.

SLOVENIA

EXECUTIVE SUMMARY

The implementation of the C4G approach in Slovenia took place from February to August 2020 as a one-week winter school, one course and two workshops. Due to the pandemic COVID -19 the course was moved to the virtual classroom. All other activities took place in the classroom.

Teachers (N_T=5) from the UL project team participated in the validation study and organized game-based learning activities with primary school students (N_S=50). Activities from C4G learning scenarios were used in the testing. The initial lessons were guided, and later students worked individually or in pairs using prepared instructions for students, with teacher assistance and further explanation of individual programming concepts if necessary. The prepared instructions were also given to the students in the virtual classroom, they could write questions in the forum or ask the teacher "live" via video conference.

Data were collected using prepared tools developed within the C4G project. Students and teachers gave their opinions and observations, and an external expert was also involved in the testing (N_E=1).

The results were very positive and indicate that the game-based C4G methodology with learning by designing games was well accepted by the students. They were very motivated to solve the tasks and had a lot of fun doing them. They enjoyed learning programming concepts, collaborating with their classmates, and exploring the Snap! environment. They tried to solve the activities individually and also improved their games. Teachers and external expert also see the approach as an appropriate way to learn programming for students ages 10 to 16. During implementation, we found that some activities were too easy for some students, so we added additional tasks to each activity and left the possibility to upgrade them at their own will.

IMPLEMENTATION

Data collection tools

The validation of the C4G approach used all data collection tools provided in the C4G validation strategy:

- S1 – Preliminary questionnaire (for students)
- S2 – Follow-up questionnaire (for students)
- S3 – Student's comments
- T1 – Teacher's observations
- T2 – Teacher's comments
- E – Expert's comments

First, all questionnaires were made and distributed to participants as Word documents, and later we used Google Forms for questionnaires S1 and S2 for students.

Initially, all questionnaires were prepared as Word documents and distributed to participants, later Google Forms for S1 and S2 questionnaires for students was used.

Materials

Learning scenarios and instructions for students were used during the implementation. A 3D platform with elements of gamification was not used because too few hours were available for testing.

The following scenarios were used in the testing:

1. Introduction to Snap! interface
2. Time to bring your sprite to life
3. Moving around the stage
4. Changing costumes and turning
5. Sounds of the farm
6. Chameleon's summer vacation
7. Helping Prince and Princess to find their animals
8. Drawing with a chalk
9. Picking up trash and cleaning the park
10. Feeding the cats
11. Guessing the number of cats in a shelter

12. Catching healthy food
13. Storytelling
14. Catch the mouse
15. Buying food for a picnic
16. Recycling
17. Play a piano 2

With selected activities, students learn all the basic programming concepts (loops, conditionals, variables, statements, operators, events, parallelism). With initial, simpler activities, students learned one programming concept, and in more challenging activities, multiple programming concepts were linked together. All scenarios and instructions for the students were translated into Slovenian before implementation.

Additional instructions (instructions for students) were prepared additionally, because after the first lesson in the course (the course was held once a week) we found that the students need some guidance to work individually.

Setup model and procedure

For the purpose of testing the C4G approach, a one-week winter school was organized, which took place during the school holidays in Ljubljana in February 2020. The winter school was attended only by girls aged between 10 and 14 years. The initial lessons were guided, after which the students solved the tasks individually or in pairs with the help of the instructions for the students. In case of problems they turned to the teachers. At the beginning of the winter school, students answered the preliminary questionnaire (S1), and at the end, students answered the follow-up questionnaire (S2). In order to compare the pretest and posttest results, students wrote a code on the questionnaires. We also collected their responses orally (S3), where they responded to our additional questions. The teachers reported on the students' participation and engagement and their learning difficulties during the implementation (T1) and on the accomplishment of the learning objectives, the relevance and effectiveness of the game-based learning, the acceptance of the proposed methodology, the fun achieved and the overall organization of the implementation (T2). The external expert also gave her qualitative opinion regarding the accomplishment of the

learning objectives, the relevance and effectiveness of the game-based learning, the acceptance of the proposed methodology, the fun achieved and the overall organization of the implementation (E).

The course started at the beginning of February 2020 in the primary school in Ljubljana and was moved to the virtual classroom in mid-March due to the pandemic COVID -19. The course was held once a week for two school hours. It was attended by students aged 10 to 14 years, who gave their answers through the S1 and S2 questionnaires.

In June and August, two one-day workshops were organized in Nova Gorica, attended by students aged 11 to 14 years who also gave their answers through the S1 and S2 questionnaires.

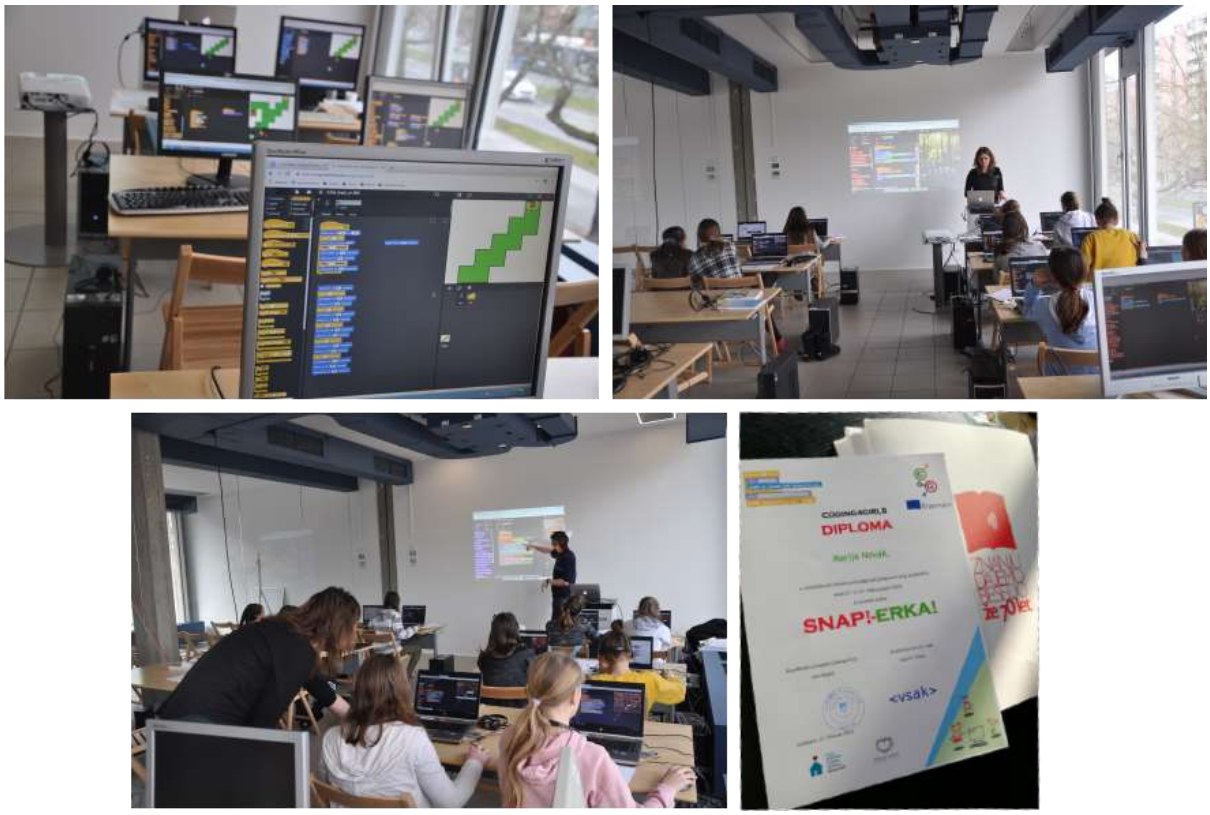

Figure 1 Testing in winter school

Participants

The project team at UL consists of researchers and teachers (N_{PT}=5) in the field of game-based learning, programming, and didactics of informatics. The whole team was actively involved in the preparation and evaluation of the activities.

The C4G approach for building programming skills was used in a one-week winter school, a course and two workshops. All testing was conducted by the UL project team. A total of 50 students aged 10 to 14 (4th to 9th grade of primary school) participated in the tests. Computer science is an elective subject in all classes. Table 1 shows the number of students-participants in the study by age/grade. Most of the students were from the 6th grade (Figure 2).

Table 1 Number of students by age/grade

Years of age	Grade	Number of students
10	4	1
10-11	5	2
11-12	6	20
12-13	7	8
13-14	8	15
14	9	4
	Total	**50**

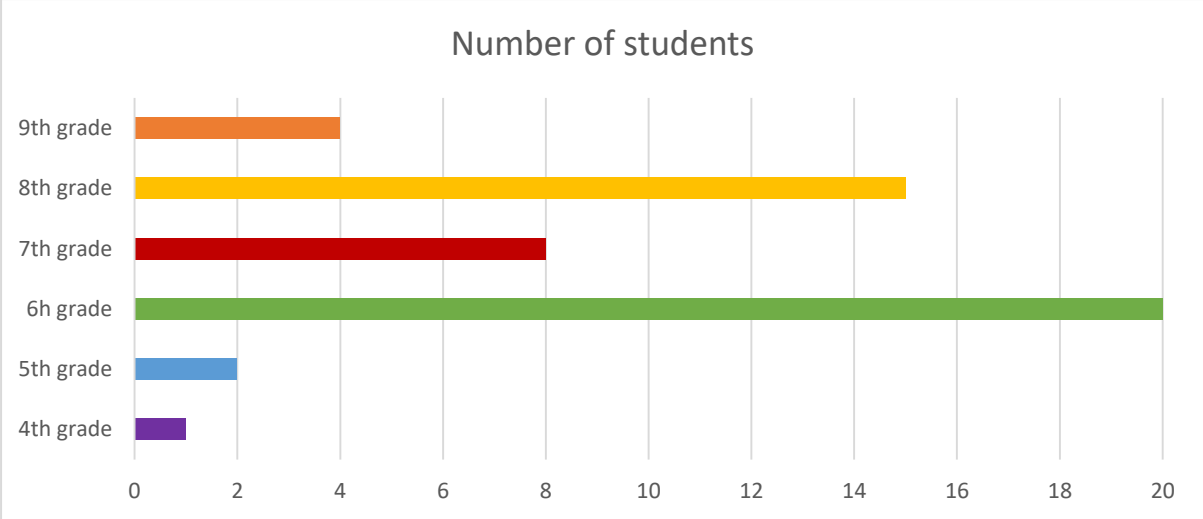

Figure 2 Number of students by grade

One external expert (N_E=1) was selected for the validation activities because of her expertise. She works as an executive director and conducts various programming workshops for primary school students.

RESULTS

Results of questionnaires for students

Students solved two questionnaires:

1. Preliminary questionnaire about digital device use and programming experience, and experience in programming, and
2. Follow-up questionnaire about satisfaction with the C4G learning methodology and the implementation of activities to acquire programming and coding skills.

In both questionnaires, students self-assessed their current level of programming skills. The results were later compared based on the students' codes.

The preliminary questionnaire was solved by 50 students (100%), while the follow-up questionnaire was solved by 43 students (86%). Self-assessment results were compared for students who solved both questionnaires - 43 students (86%).

S1 - Preliminary questionnaire

A total of 50 students solved the preliminary questionnaire about the use of digital devices and perceived level of programming. The average age of the students was 12.38 years (SD =1.260). Table 2 shows the number of students who solved S1 by gender and grade level. Slightly more girls (54%) responded to the questionnaire than boys (46%) (Figure 3).

Table 2 Number of students who solved S1 - Preliminary questionnaire by gender and grade

	4th grade	5th grade	6th grade	7th grade	8th grade	9th grade	Total
Boys	1	0	5	2	12	3	23
Girls	0	2	15	6	3	1	27
Total	**1**	**2**	**20**	**8**	**15**	**4**	**50**
Response rate	100%	100%	100%	100%	100%	100%	100%

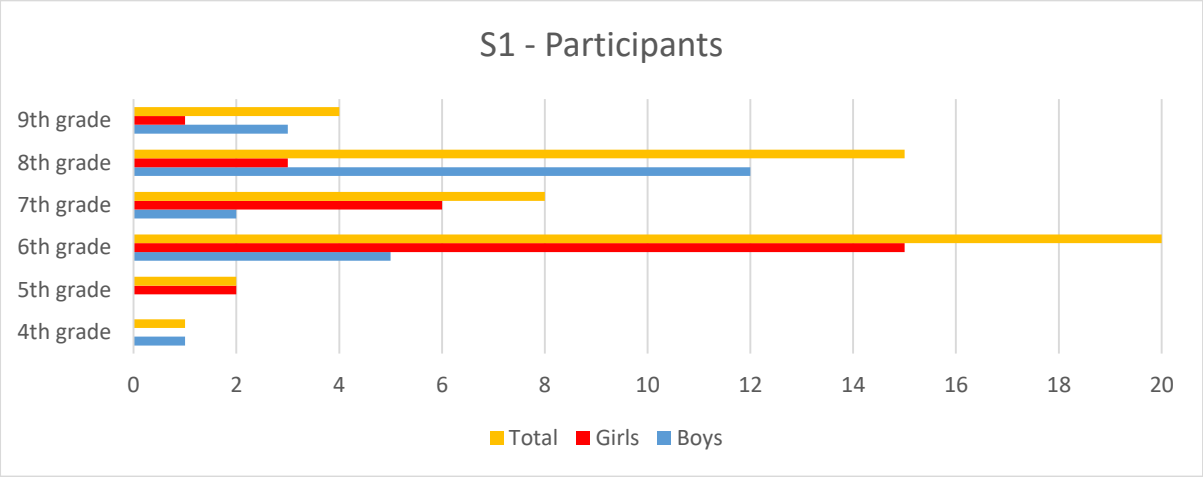

Figure 3 Distribution of students who solved S1 - Preliminary questionnaire by gender and grade

Table 3 shows the descriptive statistical analysis of the participants' responses to the questions related to the use of digital devices, internet and video games.

The standard deviation shows large deviations from the mean for some questions. Comparison of the overall mean scores by gender (Figure 4) shows that girls and boys have been using digital devices for about the same length of time, similarly is with the average hours spent using digital devices and the Internet per week. There is a slightly bigger difference when it comes to playing video games, as boys spend an average of 13 hours per week playing video games, while girls spend only 3 hours.

Table 3 The use of digital devices, the internet and video-games by gender

Question		N	Min	Max	Mean	SD
1. For how long have you been using computers, tablets or other digital devices (in years)?	Boys	23	1	9	5.91	2.31
	Girls	27	1	10	5.33	2.85
	Total	**50**	**1**	**10**	**5.60**	**2.61**
2. How many hours per week do you use a computer, tablet or other digital device?	Boys	23	0.5	84	19.89	23.6
	Girls	27	2	105	18.17	21.67
	Total	**50**	**0.5**	**105**	**18.96**	**22.36**
3. How many hours per week do you use the Internet?	Boys	23	0	84	18.08	24.38
	Girls	27	0	105	13.65	22.48
	Total	**50**	**0**	**105**	**15.69**	**23.24**
4. How many hours per week do you play video games?	Boys	23	0	84	13.09	19.58
	Girls	27	0	21	3.07	4.94
	Total	**50**	**0**	**84**	**7.68**	**14.51**

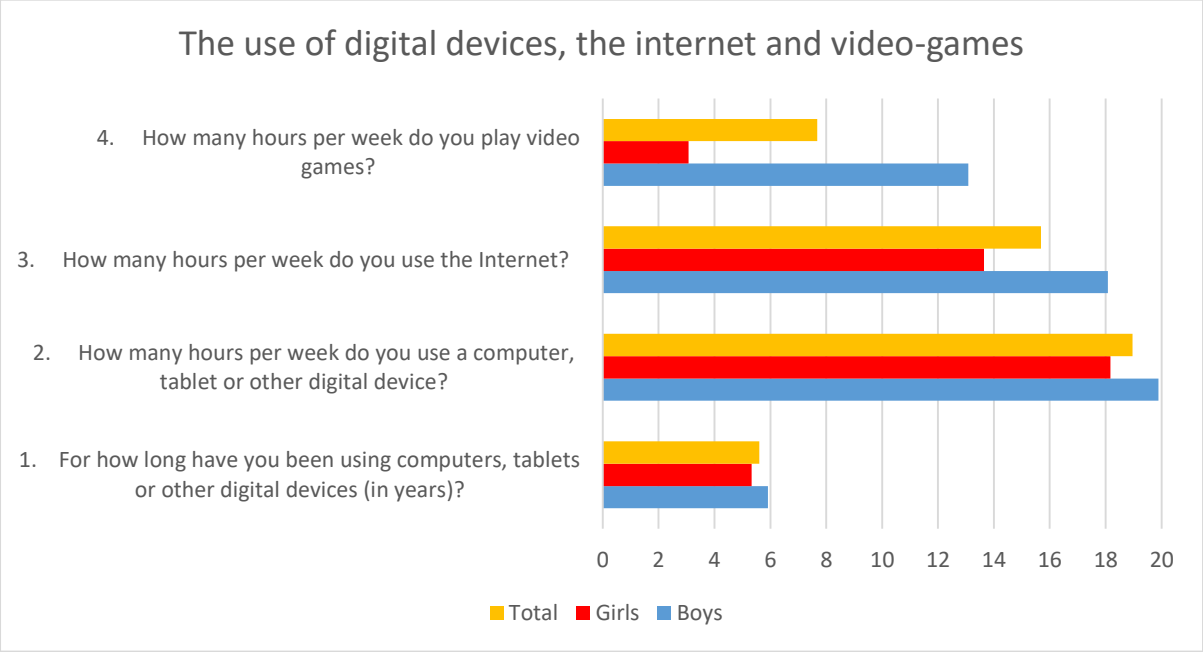

Figure 4 The use of digital devices, the internet and video-games – comparison by gender

Comparing the results by gender (Table 4), we can see that students in the upper grades (7th to 9th grade) have been using digital devices for more years, which is to be expected. When asked about the number of hours per week spent using digital devices and the Internet, we see a large variation in the standard deviation, which is due to the fact that some students answered with high values (84 hours per week by boys and 105 by girls, as can be seen in Table 3). It is also interesting to note that 8th graders spend fewer hours behind digital devices than 7th graders and most 9th graders, as expected. The standard deviation is also high for playing video games, which is also due to the high value entered by boys - 84 hours per week (Table 3).

Table 4 The use of digital devices, the internet and video-games by grade and gender

Question		4th grade	5th grade	6th grade	7th grade	8th grade	9th grade
1. For how long have you been using computers. tablets or other digital devices (in years)?	Boys	5.00	0.00	5.2	6.0	6.17	6.33
	Girls	0.00	2.75	5.00	6.25	6.67	6.00
	Total	**5.00**	**2.75**	**5.05**	**6.19**	**6.27**	**6.25**
2. How many hours per week do you use a computer. tablet or other digital device?	Boys	9.00	0.00	8.20	11.0	23.5	34.50
	Girls	0.00	2.25	21.80	8.17	23.33	40.00
	Total	**9.00**	**2.25**	**18.40**	**8.88**	**23.47**	**35.88**
3. How many hours per week do you use the Internet?	Boys	4.00	0.00	2.68	2.5	24.28	34.00
	Girls	0.00	0.75	14.17	7.42	23.33	40.00

	Total	**4.00**	**0.75**	**11.30**	**6.19**	**24.09**	**35.50**
4. How many hours per week do you play video games?	Boys	5.00	0.00	8.0	3.50	15.67	20.33
	Girls	0.00	1.25	2.43	2.27	10.33	0.00
	Total	**5.00**	**1.25**	**3.83**	**2.50**	**14.60**	**15.25**

The participants (N=50, 27 girls and 23 boys) answered a question about their programming skills, choosing the appropriate statement on a 5-point scale. The results are presented in Table 5. For both girls (37.04%) and boys (43.48%), the most common response was 2 - I can code simple programs, and none of the respondents rated their knowledge with the highest score.

Table 5 Self-assessment of programming skills by gender

Level of programming skills	**Boys**	**Girls**	**Total**
0 - I have never coded or programmed before	13.04%	29.63%	22.00%
1 - I am a novice programmer (just have basic ideas)	30.43%	25.93%	28.00%
2 - I can code simple programs	43.48%	37.04%	40.00%
3 - I am fluent in programming (can create a full program)	13.04%	7.41%	10.00%
4 - I can design a solution of a problem in the form of a program	0.00%	0.00%	0.00%

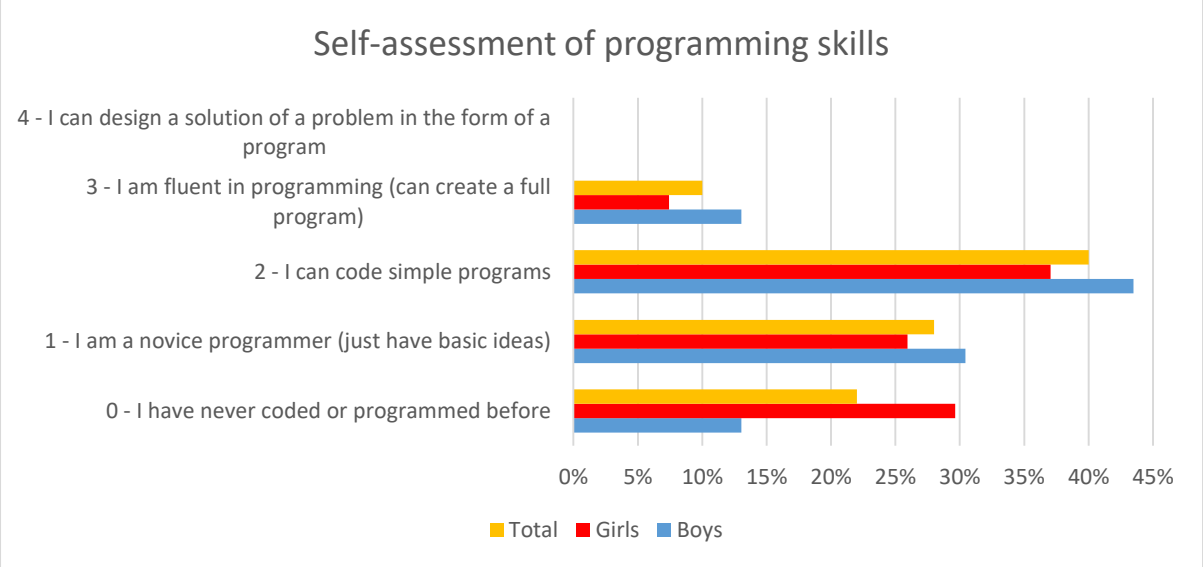

Figure 5 Self-assessment of programming skills – comparison by gender

The analysis by grades (*Table 6*) shows that the largest number of students who have never coded (level 0) is from 5th grade and not 4th, but it is worth highlighting that there

were only 3 students in both grades combined. It is also interesting to note that 7th graders rated themselves the highest on the scale (level 3, as there were no responses at level 4).

Table 6 Self-assessment of programming skills by grade and gender

Level of programming skills		**4th grade**	**5th grade**	**6th grade**	**7th grade**	**8th grade**	**9th grade**
0 - I have never coded or programmed before	Boys	0.00%	0.00%	0.00%	0.00%	25.00%	0.00%
	Girls	0.00%	50.00%	26.67%	33.33%	33.33%	0.00%
	Total	**0.00%**	**50.00%**	**20.00%**	**25.00%**	**26.67%**	**0.00%**
1 - I am a novice programmer (just have basic ideas)	Boys	0.00%	0.00%	40.00%	50.00%	33.33%	0.00%
	Girls	0.00%	50.00%	20.00%	16.67%	33.33%	100.00%
	Total	**0.00%**	**50.00%**	**25.00%**	**25.00%**	**33.33%**	**25.00%**
2 - I can code simple programs	Boys	100.00 %	0.00%	0.00%	50.00%	41.67%	100.00%
	Girls	0.00%	0.00%	53.33%	16.67%	33.33%	0.00%
	Total	**100.00 %**	**0.00%**	**40.00%**	**25.00%**	**40.00%**	**75.00%**
3 - I am fluent in programming (can create a full program)	Boys	0.00%	0.00%	60.00%	0.00%	0.00%	0.00%
	Girls	0.00%	0.00%	0.00%	33.33%	0.00%	0,00%
	Total	**0.00%**	**0.00%**	**15.00%**	**25.00%**	**0,00%**	**0.00%**
4 - I can design a solution of a problem in the form of a program	Boys	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Girls	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Total	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**	**0.00%**

The participants also stated which programming concepts they were familiar with. The results (Table 7) show that students are most familiar with *variables* (42.00%) and *loops* (38.00%) and least familiar with *parallelism* (4.00%). According to the results (Figure 6), there is not much difference in familiarity with programming concepts between genders except for the concept *conditionals* where 39.13% of boys stated that they are familiar with this concept while only 11.11% of girls stated the same.

Table 7 Familiarity with the programming concepts

Concept	**Boys**	**Girls**	**Total**
Loops	43.48%	33.33%	38.00%
Conditionals	39.13%	11.11%	24.00%
Variables	39.13%	44.44%	42.00%
Statements (sounds, movement, looks, drawing)	34.78%	29.63%	32.00%
Operators	17.39%	18.52%	18.00%

Events	39.13%	33.33%	36.00%
Parallelism	4.35%	3.70%	4.00%

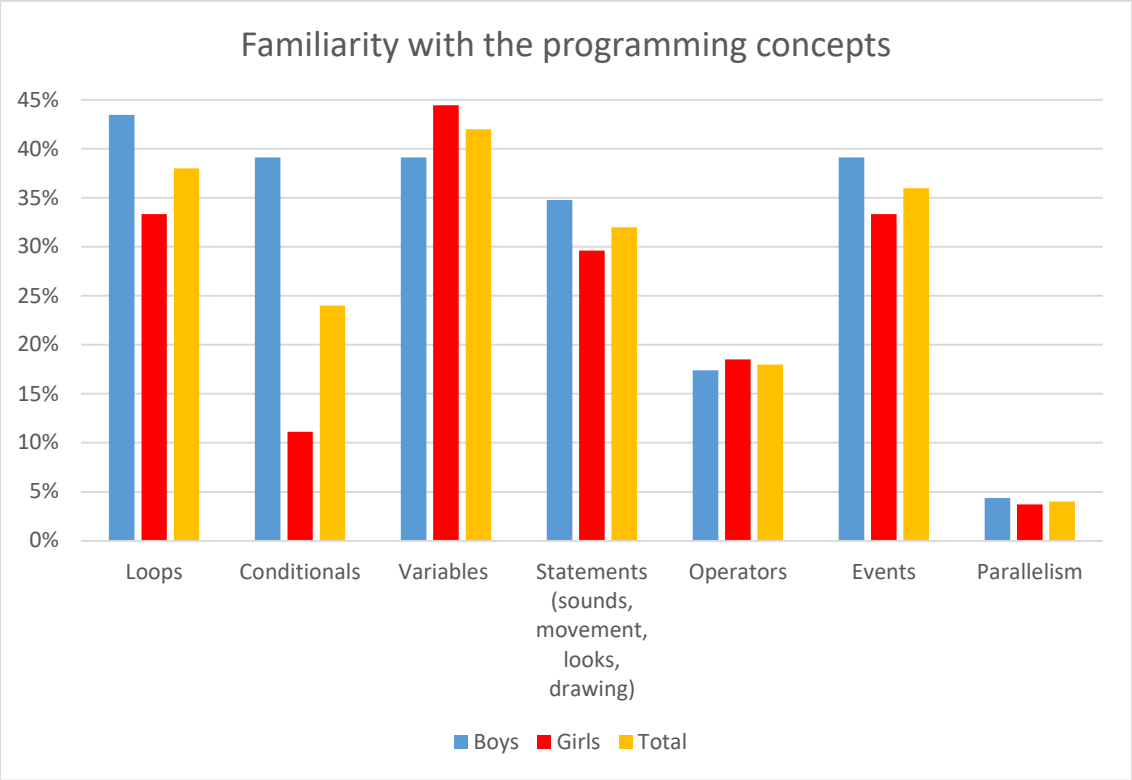

Figure 6 Familiarity with the programming concepts – comparison by gender

Comparison of the results (**Errore. L'origine riferimento non è stata trovata.**)[1] shows that 7th (50.00%), 8th (46.67%) and 9th (75%) graders are most familiar with *loops*, while 6th graders are most familiar with *variables* (50%).

Table 8 Familiarity with the programming concepts by grade and gender

Concept		4th grade	5th grade	6th grade	7th grade	8th grade	9th grade
Loops	Boys	100.00%	0.00%	0.00%	50.00%	41.7%	100.00%
	Girls	0.00%	50.00%	20.00%	50.00%	66.67%	0.00%
	Total	**100.00%**	**50.00%**	**15.00%**	**50.00%**	**46.67%**	**75.00%**
Conditionals	Boys	100.00%	0.00%	20.00%	0.00%	33.33%	100.00%
	Girls	0.00%	0.00%	0.00%	33.33%	33.33%	0.00%
	Total	**100.00%**	**0.00%**	**5.00%**	**25.00%**	**33.33%**	**75.00%**
Variables	Boys	100,00%	0.00%	60.00%	0.00%	33.33%	33.33%
	Girls	0.00%	0.00%	46.67%	33.33%	66.67%	100.00%
	Total	**100.00%**	**0.00%**	**50.00%**	**25.00%**	**40.00%**	**50.00%**

[1] For the same reason as in Table 6 we took into account only results from 6th to 9th grade.

Statements (sounds, movement, looks, drawing)	Boys	100.00%	0.00%	40.00%	0.00%	33.33%	33.33%
	Girls	0.00%	0.00%	26.67%	50.00%	33.33%	0.00%
	Total	**100.00%**	**0.00%**	**30.00%**	**37.50%**	**33.33%**	**25.00%**
Operators	Boys	0.00%	0.00%	60.00%	0.00%	8.33%	0.00%
	Girls	0.00%	0.00%	20.00%	16.67%	33.33%	0.00%
	Total	**0.00%**	**0.00%**	**30.00%**	**12.50%**	**13.33%**	**0.00%**
Events	Boys	100.00%	0.00%	80.00%	0.00%	33.33%	0.00%
	Girls	0.00%	0.00%	26.67%	50.00%	66.67%	0.00%
	Total	**100.00%**	**0.00%**	**40.00%**	**37.50%**	**40.00%**	**0.00%**
Parallelism	Boys	0.00%	0.00%	0.00%	0.00%	8.33%	0.00%
	Girls	0.00%	0.00%	6.67%	0.00%	0.00%	0.00%
	Total	**0.00%**	**0.00%**	**5.00%**	**0.00%**	**6.67%**	**0.00%**

The results show that 9th graders are most familiar with loops, conditionals and variables, 8th and 6th graders with events, 7th graders with statements and 6th graders with operators.

Table 9 shows participants' responses regarding their motivation for learning programming, where they had to select one or more answers. Most students enjoy solving logic problems and puzzles (44.00%). This was also the main motivating factor for girls (48.15%), while 39.13% of boys agreed. The main motivating factor for boys was that they want to follow a career in programming (43.48%), while only 14.81% of girls agreed with them.

Table 9 Motivation for learning programming

Response	**Boys**	**Girls**	**Total**
I'm not motivated	0.00%	3.70%	2.00%
I want to succeed in the programming class	34.78%	33.33%	34.00%
I want to show other students I can program	13.04%	3.70%	8.00%
I want to follow a career in programming	43.48%	14.81%	28.00%
I enjoy solving logic problems and puzzles	39.13%	48.15%	44.00%

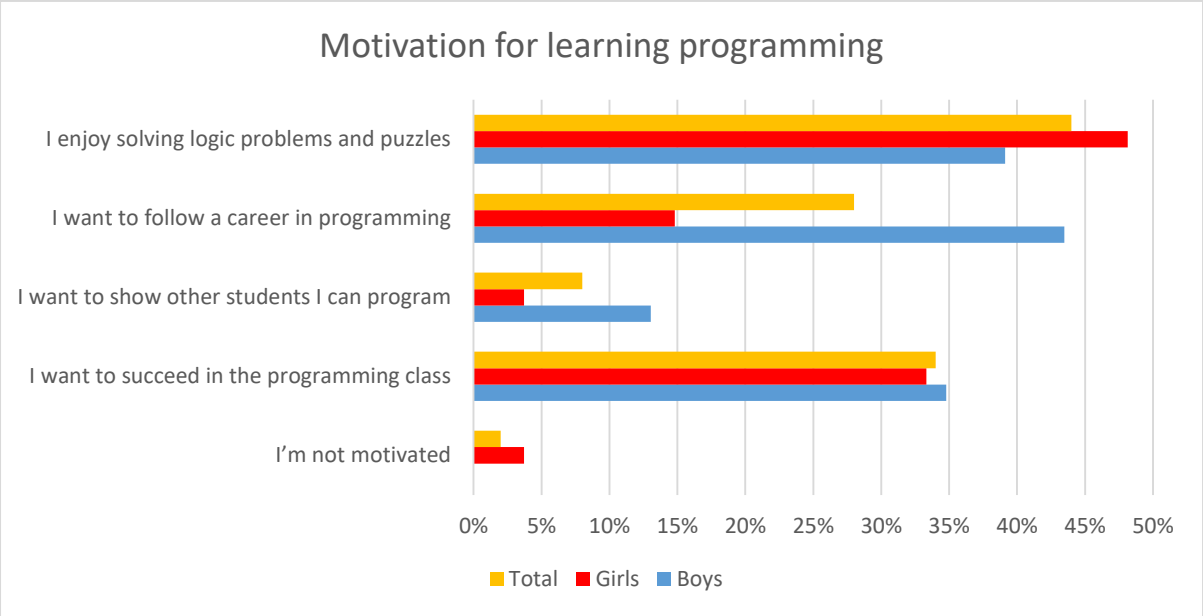

Figure 7 Motivation for learning programming – Comparison by gender

Comparison by grade (Table 10) show that 9th graders enjoy solving logic problems and puzzles the most, 8th graders want to follow a career in programming, while 6th and 7th graders want to succeed in programming class and also enjoy solving logic problems and puzzles.

Table 10 Motivation for learning programming by grade and gender

Statement		4th grade	5th grade	6th grade	7th grade	8th grade	9th grade
I'm not motivated	Boys	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Girls	0.00%	0.00%	0.00%	16.67%	0.00%	0.00%
	Total	**0.00%**	**0.00%**	**0.00%**	**12.50%**	**0.00%**	**0.00%**
I want to succeed in the programming class	Boys	0.00%	0.00%	40.00%	100,00%	33.33%	0.00%
	Girls	0.00%	50.00%	40.00%	33.33%	0.00%	0.00%
	Total	**0.00%**	**50.00%**	**40.00%**	**50.00%**	**26.67%**	**0.00%**
I want to show other students I can program	Boys	0.00%	0.00%	60.00%	0.00%	0.00%	0.00%
	Girls	0.00%	0.00%	0.00%	16.67%	0.00%	0.00%
	Total	**0.00%**	**0.00%**	**15.00%**	**12.50%**	**0.00%**	**0.00%**
I want to follow a career in programming	Boys	0.00%	0.00%	40.00%	0.00%	58.33%	33.33%
	Girls	0.00%	0.00%	6.67%	16.67%	66.67%	0.00%
	Total	**0.00%**	**0.00%**	**15.00%**	**12.50%**	**60.00%**	**25.00%**
I enjoy solving logic problems and puzzles	Boys	100.00%	0.00%	60.00%	0.00%	16.67%	100.00%
	Girls	0.00%	50.00%	46.67%	66.67%	33.33%	0.00%
	Total	**100.00%**	**50.00%**	**50.00%**	**50.00%**	**20.00%**	**75.00%**

Participants also had the opportunity to write what else motivates them to learn programming. They stated: "*I like programming because it is fun*", "*Programming relaxes me*", "*I want to design my own game*", "*I want to see if this profession is right for me*".

S2 – Follow-up questionnaire

A total of 43 students solved the follow-up questionnaire about satisfaction with programming and coding activities, satisfaction with the organization of the implementation, and perception on the acquired coding skills. The mean age of students was 12.49 years (SD=1.222). Table 11 shows the number of students who solved the S2 questionnaire by gender and grades. The number of girls and boys who solved the questionnaire is about the same in overall, but there are big differences by each grade, as can be seen in Table 11 and Figure 8.

Table 11 Number of students who solved S2 - Follow-up questionnaire by gender and grades

	5th grade	6th grade	7th grade	8th grade	9th grade	Total
Boys	0	4	2	12	3	21
Girls	1	14	5	2	0	22
Total	**1**	**18**	**7**	**14**	**3**	**43**
Response rate	50%	90%	86%	93%	75%	86%

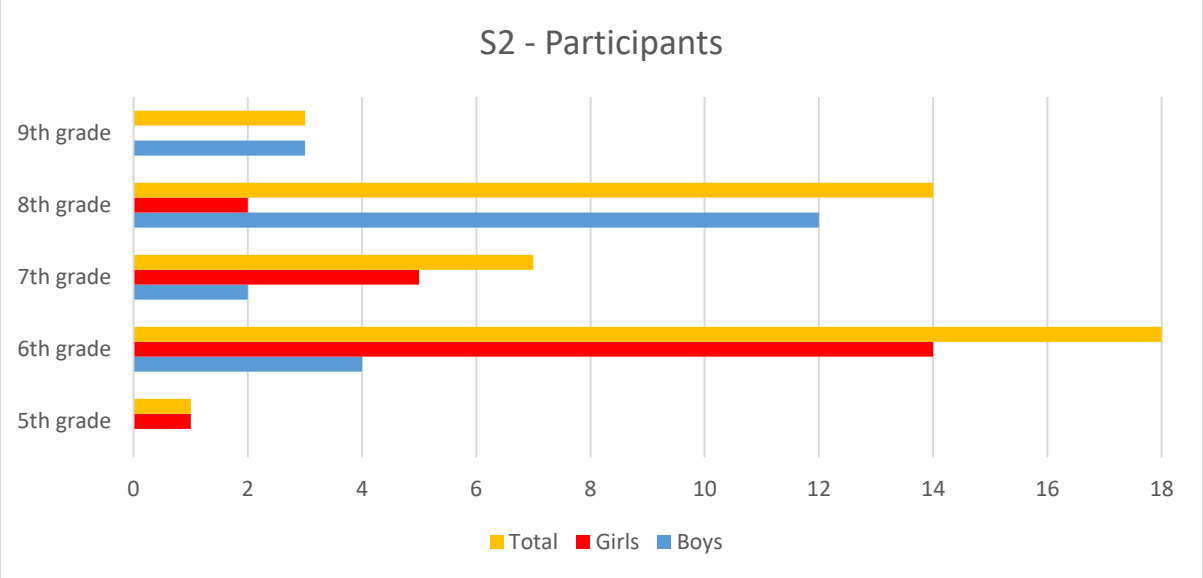

Figure 8 Distribution of students who solved S2 - Follow-up questionnaire by gender and grades

In the follow-up questionnaire, participants expressed their attitudes towards the C4G learning methodology and the implementation of the activities using the 5-point Likert scale (1 - strongly disagree, 2 - disagree, 3 - neutral, 4 - agree, 5 - strongly agree). According to the results (**Errore. L'origine riferimento non è stata trovata.**), both girls and boys enjoyed programming (mean response 4.58), felt engaged with this type of learning (4.35), and indicated that this type of learning was fun (4.30).

Table 12 Satisfaction with C4G learning methodology

Statement		1	2	3	4	5	AVG	SD
1. I found programming challenging.	Boys	9.52%	9.52%	19.05%	47.62%	14.29%	3.48	1.17
	Girls	4.55%	22.73%	13.64%	31.82%	27.27%	3.55	1.26
	Total	**6.98%**	**16.28%**	**16.28%**	**39.53%**	**20.93%**	**3.51**	**1.20**
2. I found programming motivating.	Boys	0.00%	0.00%	4.76%	61.90%	33.33%	4.29	0.56
	Girls	0.00%	0.00%	9.09%	72.73%	18.18%	4.09	0.53
	Total	**0.00%**	**0.00%**	**6.98%**	**67.44%**	**25.58%**	**4.19**	**0.55**
3. I found programming easy.	Boys	0.00%	9.52%	33.33%	47.62%	9.52%	3.57	0.81
	Girls	0.00%	9.52%	42.86%	38.10%	9.52%	3.48	0.80
	Total	**0.00%**	**9.52%**	**38.10%**	**42.86%**	**9.52%**	**3.52**	**0.80**
4. I enjoyed programming.	Boys	0.00%	0.00%	4.76%	28.57%	66.67%	4.62	0.59
	Girls	0.00%	0.00%	4.55%	36.36%	59.09%	4.55	0.60
	Total	**0.00%**	**0.00%**	**4.65%**	**32.56%**	**62.79%**	**4.58**	**0.59**
5. I understood most of programming concepts.	Boys	0.00%	4.76%	14.29%	33.33%	47.62%	4.24	0.89
	Girls	0.00%	0.00%	27.27%	40.91%	31.82%	4.05	0.79
	Total	**0.00%**	**2.33%**	**20.93%**	**37.21%**	**47.62%**	**4.14**	**0.60**
6. Learning this way is fun.	Boys	0.00%	4.76%	14.29%	33.33%	47.62%	4.24	0.60
	Girls	0.00%	0.00%	9.09%	45.45%	45.45%	4.36	0.66
	Total	**0.00%**	**2.33%**	**11.63%**	**39.53%**	**46.51%**	**4.30**	**0.62**
7. I felt engaged with this way of learning.	Boys	0.00%	0.00%	4.76%	52.38%	42.86%	4.38	0.59
	Girls	0.00%	0.00%	9.09%	50.00%	40.91%	4.32	0.65
	Total	**0.00%**	**0.00%**	**6.98%**	**51.16%**	**41.86%**	**4.35**	**0.61**

8. The activities were relevant to learn.	Boys	0.00%	0.00%	14.29%	28.57%	57.14%	4.43	0.75
	Girls	0.00%	0.00%	18.18%	45.45%	36.36%	4.18	0.73
	Total	**0.00%**	**0.00%**	**16.28%**	**37.21%**	**46.51%**	**4.30**	**0.74**
9. At any time, it was clear what I had to do.	Boys	0.00%	4.76%	33.33%	47.62%	14.29%	3.71	0.78
	Girls	0.00%	9.09%	40.91%	45.45%	4.55%	3.45	0.74
	Total	**0.00%**	**6.98%**	**37.21%**	**46.51%**	**9.30%**	**3.58**	**0.76**
10. What I learned will be relevant for my future.	Boys	0.00%	0.00%	9.52%	42.86%	47.62%	4.38	0.67
	Girls	0.00%	9.09%	22.73%	45.45%	22.73%	3.82	0.91
	Total	**0.00%**	**4.65%**	**16.28%**	**44.19%**	**34.88%**	**4.09**	**0.84**

Participants again self-assessed their programming skills on a scale from 0 - *I have never coded or programmed before* to 4 - *I can design a solution of a problem in the form of a program*. A total of 43 students (22 girls and 21 boys) completed the preliminary and the follow-up questionnaire so their self-assessment results were compared. Table 13 shows the difference on their initial and final level of programming skills. 75% of students reported that they had made progress, most of them (49%) for 1 level and 27% of them for 2 levels, while 26% of students remained at the same level. A comparison by gender shows that girls made more than boys (8% more girls have progressed for 1 level and 3% for 2 levels), while 15% more boys remained at the same level. None of the students indicated that they had regressed in their programming skills.

Table 13 - The difference between the self-assessed levels of programming skill

	Difference		
	0	**1**	**2**
Boys	33%	43%	24%
Girls	18%	55%	27%
Total	**26%**	**49%**	**26%**

A Wilcoxon's signed rank test for paired samples with Exact test showed that students self-assessed their programming skill significantly higher after the C4G activities compared to self-assessment before the C4G activities (Table 14).

The effect size is calculated with formula $r=\frac{Z}{\sqrt{n}}$, where Z is z- statistics obtained from Wilcoxon signed rank test (SPSS), n is number of observations. The results show large effect size overall and by gender.

Table 14 Comparison of self-assessment of programming skill

		Descriptive statistics					Wilcoxon's signed rank test results		
		N	**MIN**	**MAX**	**MEAN**	**SD**	**Z**	**p**	**Effect size**
Boys	S1	21	0	3	1.48	.873	-3,416	.000 (exact sig. 0,000)	-0,74543
	S2	21	1	4	2.38	.921			
Girls	S1	22	0	3	1.23	.922	-3,874	.000 (exact sig. 0,000)	-0,82594
	S2	22	1	4	2,32	.945			
Total	**S1**	**43**	**0**	**3**	**1.35**	**.897**	**-5.138**	.000 (exact sig. 0,000)	**.** -0.78354
	S2	**43**	**1**	**4**	**2.35**	**.923**			

Students' comments

Students in their comments stated that they liked this way of learning a lot and that it was really fun and interesting. They enjoyed in designing games and found gathered knowledge very useful. Learning by designing games was fun, interesting and "*much more fun than traditional learning*".

The students liked the methodology and most would not change anything. Some said it would be fun if they could choose a theme for the game by themselves.

Teachers' observations and comments

After the implementation, the teachers presented their observations and comments in a qualitative way through open-ended questions.

Teachers' observations

Using the T1 form teachers (NT=5) reported on students' participation and engagement and their learning difficulties during the implementation.

All teacher stated that students were actively involved in the activities. They were motivated for work, discuss, collaborate and help each other while participating in the activities. They had a lot of fun developing games. Some students which had some previous experience in programming were more independent and often did even more than excepted. They were all motivated to learn new functionalities to implement them in the game. They also enjoyed playing the finished games and participating in them.

Novice programmers with no previous experience needed more support in the beginning, but with some assistance and hints from teachers, they were able to quickly start programming and experimenting in the Snap environment. Other problems at the beginning were mostly due to not listening to the teacher and not reading the instructions on the worksheets. In both cases, they felt comfortable asking for support when they could not solve the situation with their colleagues or on their own.

Students were very interested and motivated to learn programming. They enjoyed programming their games. The first lessons (1-4) were not so interesting for the students who already knew Scratch, but later, when they started creating real games, they said it was awesome and really interesting.

Teachers' comments

Using the T2 form, teachers (N_T=5) reported on accomplishment of learning objectives, relevance and effectiveness of game-based learning, acceptance of the proposed methodology, achieved fun, and the overall organization of the implementation.

In a 5-day winter school students achieved all the objectives that were planned for course: Adding a new sprite, adding a costume to a sprite and edit it, Adding a new background and edit it, Moving a sprite, Making sprite say something, Using loop repeat, Changing sprite's costume, Adding sound, Using events, Using if sentence, Drawing, Changing background, Using variables, Random numbers, String concatenation Operators, Input, and Broadcast.

All teachers indicated that the working methods and materials were well prepared. It was found that the learning approach had a great influence on the motivation of the students and therefore on the competences achieved. As they were designing a game, they

were able to consider the concepts in the appropriate context. They were motivated to improve the original game by adding functionalities that went beyond the expected skill level simply because they wanted to make their game better and have more fun playing it. Suddenly, relatively complex concepts were no longer difficult to understand, and that is the biggest benefit of this approach. Specific adaptations of teaching materials and working methods for girls also proved successful.

The students accepted and enjoyed working with the proposed methodology. They were very engaged, focused and motivated. They love playing games and this approach gave them the opportunity to design their own simple game. The relatively complex learning content of programming, which is often perceived as difficult and boring, was presented in a fun and meaningful way that the students enjoyed.

Students enjoyed active learning and collaborating with their peers and had fun. Most importantly, even though they had fun, they achieved great results and learned many new concepts.

The organization of the implementation was carefully prepared. The complexity of the learning content and programming tasks in the course gradually increases so that students can effectively progress in the learning process. The games they program become more and more interesting and present a real challenge for students who spend most of their time in the zone of proximal development.

Teachers' and students' comments on the appropriateness of prepared learning materials for girls

At our multiplier event we asked teachers (N_{Tme}=9) and students (N_{Sme}=4) about the appropriateness of the prepared scenarios for girls. All agreed that the topics of the prepared activities in Snap! were appropriate and motivating for girls.

Experts' comments

External validator - expert (N_E=1) was also asked to give her qualitative opinion regarding the accomplishment of learning objectives, relevance and effectiveness of game-

based learning, acceptance of the proposed methodology, achieved fun, and the overall organization of the implementation.

External expert stated that the implementation offered involving exercises and was well accepted by the students. Students have learned the basic programming concepts in a fun way with teachers who were positive and made a great connection with the group. Majority of the teachers were women (as well as students were all girls in this course) which is very important for girls, so they could identify with them as their role-models.

External expert noted that the implementation involved exercises and was well accepted by the students. Students learned basic programming concepts in a fun way with teachers who were positive and connected well with the group. The majority of the teachers were women (as the students in this course were all girls), which is very important for girls to identify with as role models.

Her estimation is that the students very well accepted the proposed methodology, perhaps even more so the youngest among them. Some of the games they designed could have been less appealing for the oldest students. She would recommend diversifying the learning materials for students older than 13 and creating other stories/scenarios for them where there is less talk about designing games and more focus on solving a problem.

The students definitely enjoyed learning the programming concepts. They were very often motivated to understand and learn the concepts so they could solve/program the solutions of the activities. The learning materials are well designed and excellently presented to the participating students.

The design thinking educational framework is probably the best approach in different learning situations, especially when you have the opportunity to teach in a learning-by-doing situation. Using the design thinking approach, important social/cultural/environmental issues and problems can be observed, discussed and reflected upon in terms of the impact of the solutions created on their users and society.

This C4G program is a well needed for two reasons: it targets girls who are not typically encouraged in their socialization to use and explore technology creatively; learning scenarios that call for solutions to a problem or people or animals in need of help. In this way, they could be further developed and linked to different subjects and topics from the technical or social sciences.

DISCUSSION AND CONCLUSIONS

The results of the preliminary questionnaire (S1) show that girls and boys use digital devices and the Internet a few hours a day and have experience in them between 5 and 6 years. A greater difference between the genders is shown when it comes to playing video games, where boys play 2 hours per day while girls only one hour. High values in the use of digital devices and internet can also be attributed to the pandemic, as responses after the pandemic are 60% higher in digital device use, 45% higher in internet use, and 43% higher in playing video games than before. Due to the lower interest of girls in video games, it is even more important that we motivate them well to play and also to design games, which we definitely achieved with the C4G approach.

The results show that almost all students are motivated to learn programming, which is expected of our participants since they all participated in testing in their free time. The girls are most motivated by solving logic problems and puzzles, while the biggest motivating factor for the boys is the desire to make a career in programming. This answer showed the largest gender gap, which is in line with the picture in the world, as only a small percentage of women are employed in the field of computer science. Therefore, such an approach is recommended to get girls interested in programming and show them that they too can be successful in the field of computer science.

In the preliminary questionnaire, most students rated their programming skills as level 1 (they are novice programmers) and level 2 (they can code simple programs). None of the participants rated their knowledge at the maximum level 4 (they can design a solution of a problem in the form of a program). The answers are also consistent with the results related to knowledge of programming concepts, where all concepts were rated quite low (most students know variables - 42%, followed by loops - 38%, statements - 33%, etc.).

The teachers and an external expert also gave their opinion on the implementation. All of them agreed that the students learned a lot, were very motivated in their learning and had a lot of fun. At the online (multiplier) event we also showed the prepared activities to a wide audience of teachers and students all over Slovenia, who were enthusiastic about the activities and will be happy to use them in their lessons.

Comparisons between students' responses regarding their knowledge of programming skills before and after implementation also show that almost half of the students (49%) progressed by one level, while just over a quarter (26%) progressed by two levels or stayed at the same level, and no one regressed.

Similar to the teachers and external expert, the approach was also very well received by the students. During the implementation there was a sense of collaboration, interest and motivation among the students to design games, many students also added their own ideas and were happy to help their classmates.

The C4G methodology has proved very useful and is well received by students aged 10 to 16. Of course, the methodology still leaves room for improvement, such as more challenging tasks for more able students, adding activities and bringing the tasks even closer to real-life problems.

ANNEXES

S1. PRELIMINARY QUESTIONNAIRE FOR STUDENTS (in Slovenian)

S1. VPRAŠALNIK ZA UČENCE pred izvajanjem tečaja

To je začetni vprašalnik o uporabi digitalnih naprav in izkušnjami iz programiranja. Raziskava je izvedena v okviru projekta CODING4GIRLS, katerega namen je uporabiti pristop učenja z igrami za spodbujanje razvoja veščin programiranja pri učencih.
Tvoji odgovori bodo **anonimni** in bodo uporabljeni le v raziskovalne namene. Hvala za tvoj čas in sodelovanje!
Najprej **napiši kodo**, ki si jo prejel od učitelja!

KODA IN SPLOŠNE INFORMACIJE

Koda: _____ Šola: _____

Starost: _____ Razred: _____

Spol: M Ž

UPORABA DIGITALNIH NAPRAV, INTERNETA IN VIDEO IGER

1. Koliko let že uporabljaš računalnik, tablico ali druge digitalne naprave?	_____ let
2. Koliko ur na teden uporabljaš računalnik, tablico ali druge digitalne naprave?	_____ ur
3. Koliko ur na teden uporabljaš internet?	_____ ur
4. Koliko ur na teden igraš video igre?	_____ ur

IZKUŠNJE V PISANJU KODE IN PROGRAMIRANJU

5. Kakšen je tvoj nivo znanja iz programiranja? *Obkroži najbolj primeren odgovor.*
   a) Nikoli še nisem pisal/a kode oz. programiral/a
   b) Sem novinec/ka pri programiranju (imam le osnovne ideje)
   c) Napisati znam preproste programe
   d) Napisati znam zahtevnejše programe (znam napisati celoten program)
   e) Znam oblikovati rešitev in jo zapisati v obliki programa

6. Če si se že srečal/a s programiranjem, kateri od spodnjih konceptov so ti poznani? *Obkrožiš lahko več odgovorov.*

☐ Zanke (Loops) ☐ Spremenljivke (Variables) ☐ Dogodki (Events)

☐ Pogojni stavki (Conditionals) ☐ Operatorji (Operators) ☐ Vzporednost (Parallelism)

☐ Ukazi za zvok, premikanje, izgled, risanje (Statements - sounds, movement, looks, drawing)

7. Kaj te motivira za učenje programiranja? *Obkrožiš lahko ve odgovorov.*
   - ☐ Nisem motiviran/a
   - ☐ Želim uspeti pri pouku programiranja
   - ☐ Drugim učencem želim pokazati, da znam programirati
   - ☐ Želim si nadaljevati poklicno pot na področju programiranja
   - ☐ Uživam v reševanju logičnih problemov in ugank
   - ☐ Drugo _____

S2. FOLLOW-UP QUESTIONNAIRE FOR STUDENTS (in Slovenian)

S2. VPRAŠALNIK ZA UČENCE po končanem tečaju

To je vprašalnik o zadovoljstvu s C4G učno metodologijo in izvajanjem aktivnosti za pridobivanje veščin programiranja in kodiranja.
Tvoji odgovori so **anonimni** in bodo uporabljeni le v raziskovalne namene. Hvala za tvoj čas in sodelovanje!
Spodaj napiši **kodo**, ki si jo prejel/a od učitelja (to je ista koda, kot si jo dobil/a na začetku).

KODA IN SPLOŠNE INFORMACIJE

Koda: _____ Šola: _____

Starost: _____ Razred: _____

Spol: M Ž

C4G UČNA METODOLOGIJA

1. Označi stopnjo strinjanja za vsako izmed spodnjih trditev:	*Sploh se ne strinjam*	*Ne strinjam se*	*Niti se strinjam, niti se ne strinjam*	*Strinjam se*	*Popolnoma se strinjam*
a) Programiranje mi predstavlja izziv.	1	2	3	4	5
b) Programiranje me motivira.	1	2	3	4	5
c) Programiranje se mi zdi enostavno.	1	2	3	4	5
d) Užival/a sem v programiranju.	1	2	3	4	5
e) Razumel/a sem večino konceptov programiranja.	1	2	3	4	5
f) Učenje na takšen način je zabavno.	1	2	3	4	5
g) Takšen način učenja me je pritegnil.	1	2	3	4	5
h) Naloge so bile uporabne.	1	2	3	4	5
i) Vedno sem vedel/a, kaj moram narediti.	1	2	3	4	5
j) Pridobljeno znanje je pomembno za mojo prihodnost.	1	2	3	4	5

NIVO ZNANJA IZ PROGRAMIRANJA

2. Kakšen je sedaj tvoj nivo znanja iz programiranja? *Obkroži najustreznejši odgovor.*
   f) Nikoli še nisem pisal/a kode oz. programiral/a
   g) Sem novinec pri programiranju (imam le osnovne ideje)
   h) Napisati znam preproste programe
   i) Napisati znam zahtevnejše programe (znam napisati celoten program)
   j) Znam oblikovati rešitev in jo zapisati v obliki programa

S3. STUDENT'S COMMENTS (in Slovenian)

S3. KOMENTARJI UČENCEV

Prosimo učitelje, da po izvedbi učnih aktivnosti za usvajanje programerskih veščin, ki temelji na metodi učenja z izdelavo iger in smo ga razvili v okviru projekta Coding for Girls (C4G), od učencev s skupinskim intervjujem pridobite njihova mnenja in komentarje.
Učence povprašajte o vidikih, ki so navedeni spodaj, in jih vnesite v obrazec.
Hvala za vaš čas in sodelovanje!

SPLOŠNE INFORMACIJE

Učitelj: _____ Razred: _____

Šola: _____ Datum: _____

SPLOŠNA ORGANIZACIJA IN DOJEMANJE UČENCEV

Učence lahko vprašate o celotni izvedbi dela predmeta, njihovem dojemanju pridobljenega znanja, učinkovitosti učenja z igrami, zabavnosti ipd.

Primer:
Kaj si se naučil/a?
Kakšno se ti je zdelo učenje z izdelavo iger?
Ali je bilo izdelovanje iger zabavno?

UČNE TEŽAVE

Učence vprašajte o i učnih ali drugih težavah, s katerimi so se srečevali med izvedbo, in o tem, kaj so storili, ko so naleteli na težave.

Primer:
Ali si imel/a težave pri izdelovanju iger?
Kaj si naredil/a,če si imel/a težave?

PREDLOGI UČENCEV KAKO IZBOLJŠATI C4G METODOLOGIJO, ORODJE IN VSEBINO

Primer:
Imaš kakšen predlog, kako bi izboljšal/a takšen način učenja (z igrami)?

Kaj bi dodal/a, kaj bi spremenil/a?

KARKOLI DRUGEGA, KAR SE JIM ZDI POMEMBNO

Primer:

Bi dodal/a kakšno drugo tematiko za igre?

Imaš kakšne druge predloge glede izvedbe take oblike učenja?

T1. TEACHER'S OBSERVATIONS (in Slovenian)

T1. UČITELJEVA OPAŽANJA IN UGOTOVITVE
Med izvedbo učnih ur ste učitelji opazovali in dokumentirali odzive ter napredek učencev pri pridobivanju programerskih veščin z uporabo "C4G pristopa učenja z izdelavo iger". Prosimo vas, da navedete svoja opažanja glede spodaj navedenih vidikov. Hvala za vaš čas in sodelovanje!
SPLOŠNE INFORMACIJE
Učitelj/ica: _____ Razred: _____ Šola: _____ Datum (od-do): _____
SODELOVANJE IN VKLJUČENOST UČENCEV
So bili učenci med učno uro aktivni? So sodelovali z učiteljem in med sabo? So se zabavali? Ipd.
UČNE TEŽAVE
Imajo učenci težave pri učenju in / ali z uporabljeno tehnologijo? Ali so vas prosili za pomoč? Ipd.
DRUGA OPAŽANJA, KI SE VAM ZDIJO POMEMBNA

T2. TEACHER'S COMMENTS (in Slovenian)

T2. UČITELJEVI KOMENTARJI
Po izvedbi učnih ur na osnovi »C4G pristopa za usvajenje programerskih veščin« zbiramo mnenja in komentarje učiteljev. Prosimo, da izpolnete vprašalnik in podate svoje mnenje o spodaj navedenih vidikih. Hvala za vaš čas in sodelovanje!
SPLOŠNE INFORMACIJE
Učitelj/ica: _____ Razred: _____ Šola: _____ Datum: _____
DOSEGANJE UČNIH CILJEV S STRANI UČENCEV
USTREZNOST IN UČINKOVITOST UČENJA Z UPORABO IGER ZA GRADNJO VEŠČIN PROGRAMIRANJA IN SPRECIFIČNEGA CODING4GIRLS UČNEGA PRISTOPA
SPREJEMANJE PREDLAGANE METODE UČENJA S STRANI UČENCEV
DOSEŽENA STOPNJA ZABAVNOSTI PRI UČENCIH

VAŠE MNENJE O IZVEDBI UČNIH UR
UPORANOST IN SPREJEMANJE PRISTOPA UČENJA S SNOVANJEM IZOBRAŽEVALNIH IGER (povezano s CODING4GIRLS pristopom učenja z izobraževalnimi igrami, snovalskim mišljenjem)
DRUGO

E. EXPERT'S COMMENTS (in Slovenian)

E. KOMENTARJI STROKOVNJAKA
Po izvedbi učnih ur na osnovi »C4G pristopa za usvajenje programerskih veščin« zbiramo mnenja in komentarje izkušenih učiteljev in strokovnjakov oz. raziskovalcev s področja didaktike. Prosimo, da izpolnete vprašalnik in podate svoje mnenje o spodaj navedenih vidikih. Hvala za vaš čas in sodelovanje!
SPLOŠNE INFORMACIJE
Ime in priimek: _____ Ustanova: _____ Položaj: _____ Datum: _____
DOSEGANJE UČNIH CILJEV S STRANI UČENCEV
USTREZNOST IN UČINKOVITOST UČENJA Z UPORABO IGER ZA GRADNJO VEŠČIN PROGRAMIRANJA IN SPRECIFIČNEGA CODING4GIRLS UČNEGA PRISTOPA
SPREJEMANJE PREDLAGANE METODE UČENJA S STRANI UČENCEV
DOSEŽENA STOPNJA ZABAVNOSTI PRI UČENCIH

VAŠE MNENJE O IZVEDBI UČNIH UR
UPORANOST IN SPREJEMANJE PRISTOPA UČENJA S SNOVANJEM IZOBRAŽEVALNIH IGER (povezano s CODING4GIRLS pristopom učenja z izobraževalnimi igrami, snovalskim mišljenjem)
DRUGO