Gender Differences in Self-efficacy for Programming Narrowed After a 2-h Science Museum Workshop

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Abstract Many girls believe they have little natural ability in computer science and girls’ perception of self-efficacy beliefs for programming is generally low. Offering engaging hands-on programming activities could be a beneficial strategy to increase girls’ self-efficacy beliefs for programming since it has the potential to offer them exposure to mastery experiences. However, a programming workshop in a museum might not offer ideal settings to promote girls’ mastery experiences in programming because of its short duration and how gender stereotypes may impact the participation in hands-on activities. In the research presented here, we explore how a science museum’s introductory programming workshop focused on robotics can impact pupils’ self-efficacy beliefs for programming related to mastery experiences, with a specific focus on girls. H1—Prior to the programming workshop, it is expected that girls’ self-efficacy beliefs will be lower than boys’. H2—Boys generally have more positive experiences with STEM activities than girls, irrespective of experimental condition. Thus, following the workshop, we predict that girls’ and boys’ self-efficacy for programming will have increased, but that boy’s self-efficacy beliefs will remain higher than girls’. In total, 172 pupils (94 girls) aged 10–14 years completed a Mastery Experiences in Programming questionnaire before and after taking part in a programming workshop. Our results show that after a 2-h programming workshop in a science museum, gender differences in self-efficacy for programming initially observed narrowed and even disappeared.

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Résumé De nombreuses filles estiment posséder peu d’aptitudes naturelles en informatique et leur sentiment d’efficacité personnelle en ce qui a trait à la programmation demeure généralement faible. Le fait de proposer des activités de programmation captivantes et pratiques peut s’avérer une stratégie efficace pour augmenter le sentiment d’efficacité personnelle des filles quant à la programmation parce que ces activités possèdent le potentiel de leur procurer de précieuses expériences de réussite. Cependant, les ateliers de programmation organisés dans les musées n’offrent pas nécessairement les meilleures conditions pour favoriser les expériences de réussite en programmation pour les filles, en raison de leur courte durée et parce que les stéréotypes liés au genre peuvent avoir des effets sur la participation aux activités pratiques. Dans cette étude, nous explorons comment un atelier d’initiation à la programmation axée sur la robotique, offert dans un musée de sciences, peut modifier le sentiment d’efficacité personnelle des élèves à l’égard de la programmation en ce qui a trait aux expériences de réussite, et ce particulièrement chez les filles. H1— Avant la tenue de l’atelier de programmation, il est attendu que le sentiment d’efficacité personnelle des filles sera plus faible que celui des garçons. H2—Ces derniers vivent généralement plus d’expériences positives dans les STIM que les filles, peu importe la condition expérimentale en cause. Ainsi, nous prédisons qu’après la tenue de l’atelier, le niveau d’efficacité personnelle à l’égard de la programmation des filles et des garçons aura augmenté, mais que celui des garçons demeurera plus élevé que celui des filles. Le nombre d’élèves âgés de 10 à 14 ans qui ont rempli un questionnaire portant sur les expériences de réussite en programmation avant et après la tenue de l’atelier est de 172, dont 94 sont des filles. Les résultats indiquent qu’après un atelier de programmation d’une durée de deux heures, tenu dans un musée de sciences, les différences entre les genres initialement observées quant à l’efficacité personnelle à l’égard de la programmation se sont amenuisées et ont même disparu.

Keywords Self-efficacy · Programming · Mastery experiences · Gender

Introduction

Programming and computational thinking (Wing, 2006) constitute a new literacy for all citizens in a digital society. Programming involves skills such as logical and systematic thinking, which can be used to solve problems encountered in various learning contexts or in daily life, beyond the professional field of computer science (Tsai et al., 2019). For this reason, in recent years, programming skills have been included in the school curriculum standards of several countries (e.g. in Canada: Government of Quebec [Gouvernement du Québec], 2018; in Taiwan: Ministry of Education, 2016; in the United States: National Science Foundation [NSF], 2016). One challenge faced in teaching programming in K-12 settings is to address the persistent underrepresentation of women in computer science, which is an important topic for economic and social justice reasons (Beyer, 2014). Computer science has one of the lowest shares of women degree recipients among science, technology, engineering and mathematics (STEM) fields, and the share of women receiving bachelor’s and doctorate degrees has declined over time (NSF, 2019). In the USA, only 19% of computer science degrees were awarded to women in 2016 compared to 27% in 1997 (NSF, 2019), and only 0.4% of female first-year university students intended to major in computer science compared to 2.9% of their male counterparts (NSF, 2013). In Canada, the trend is comparable, in that women account for only 30% of students who graduated from mathematics and computer science programmes in the last decade (Hango, 2013) with Québec ranging below average at 19% of female computer science undergraduates (Chaire pour les femmes en sciences et en génie au Québec, 2021).

A number of variables have been proposed to account for this gender imbalance, including traditional socialization practices that reinforce STEM fields as male domains, and women’s lower confidence ratings in STEM (Wang & Degol, 2017). An important determinant of the gender gap in STEM
fields concerns the stereotype threat that women entertain about this field. Many women believe that they have little natural ability in programming (Beyer, 2014) and their perception of self-efficacy is often low (Askar & Davenport, 2009; Michie & Debra, 2006). Self-efficacy refers to people’s beliefs in their capabilities to produce given attainments and it has been shown to be a powerful predictor of one’s willingness to engage and be successful in different areas of life (Bandura, 1994). Individuals with high levels of self-efficacy approach difficult tasks as challenges to be mastered rather than threats to be avoided. They set more difficult goals for themselves, exert more active self-regulation, expend more effort, persist for longer with challenges, and show resilience in the face of adversity (Bouffard et al., 2005; Klassen & Usher, 2010; Valentine et al., 2004). It is through these mechanisms that self-efficacy enhances achievements, which in turn increases self-efficacy (Bandura, 1986).

Offering engaging hands-on programming activities could be a particularly beneficial strategy to encourage girls’ participation in computer science (Witherspoon et al., 2016). Hands-on activities have the potential to offer girls’ opportunities for mastery experiences that, through successful completion of programming-related tasks, can in turn increase girls’ self-efficacy beliefs for programming (Baker, 2013). According to Bandura (1997), significant mastery experiences arising from enactive attainment in a given realm of functioning is the major mechanism involved in structuring self-efficacy beliefs about functioning in that specific domain. However, this only happens if the person attributes the responsibility for the outcome to their abilities.

With an increasing number of science museums around the world offering introductory programming workshops, more girls are likely to be initiated to programming in these informal learning environments (e.g. Horn et al., 2008). Despite promising outcomes for improving girls’ self-efficacy for programming, workshops at science museums can pose challenges in addressing gender issues (Dawson, 2014). Studies suggest that girls’ participation in science activities tends to mostly be superficial, passive, and quiet (e.g. Hansen et al., 1995; Dawson et al., 2020) or more often focus on assistance and note taking (Mewborn, 1999) while boys generally have more positive experiences with STEM activities, irrespective of experimental condition (e.g. Alexander et al., 2012; Kessels & Hannover, 2008; Hoffmann, 2002). Silfver (2019) also argues that the same gender relations and gendered biases about programming that exist in the classroom are carried out when working with robots in a museum. These stereotypes include girls being less confident than boys around technology and not as comfortable at “hands-on” experience with programming robots. Since time spent on user interface control and manipulation is crucial in gaining mastery experiences and consequently developing self-efficacy for programming, girls may be less likely to develop their skills when participating in short science museum programming workshops. In this context, further investigations considering gender equity in science museums can be beneficial for theoretical developments in gender equity issues as well as for the practical reality of informal science learning settings (Rodéhn, 2019).

In sum, science museum programming workshops might not offer an ideal setting for promoting girls’ self-efficacy beliefs for programming. Gendered patterns and the short duration of these workshops could jeopardize girls’ involvement in informal programming activities, creating a chain of circumstances where the lack of positive programming experiences can contribute to undermining self-efficacy, which in turn affects the selection of programming courses and computer science-related career choices. As a rising number of educational institutions aim to achieve gender equality in STEM and are increasing their efforts to promote girls’ participation in STEM (UNESCO, 2017), it is important to document girls’ experience relative to these initiatives. Some studies suggest that museum visits of only a few hours can significantly impact affective experiences of pupils (Martin et al., 2016; Dohn, 2013; Jarvis & Pell, 2002). One question that should be further explored is how beneficial hands-on programming activities offered by science museums are for the development of girls’ self-efficacy for programming.
Experimental Aim and Hypotheses

In the research presented here, we explore how a science museum’s short programming workshop can impact pupils’ mastery experiences, an important source of self-efficacy beliefs, with a specific focus on girls.

**Hypothesis 1 (H1)**

Women often believe they have little natural ability in programming (Beyer, 2014) and generally tend to have low self-efficacy beliefs for programming. Thus, we expect that girls will generally report lower self-efficacy than boys before the programming workshop.

**Hypothesis 2 (H2)**

**H2.1**

Mastery experiences are acknowledged as an important factor in the development of self-efficacy (Bandura, 1994). Pupils’ participation in hands-on programming activities should offer them opportunities to control and manipulate the user interface, which is crucial to developing programming skills. Therefore, we predict that on average, pupils’ self-efficacy for programming will be higher after the workshop.

**H2.2**

Boys generally have more positive experiences with STEM activities than girls, irrespective of experimental condition (e.g. Alexander et al., 2012; Kessels & Hannover, 2008; Hoffmann, 2002). Accordingly, we predict that boys’ self-efficacy will remain higher than girls’ self-efficacy beliefs following the programming workshop.

**Methods**

**Participants**

Participants in this study are elementary and secondary school pupils aged 10–14 years from diverse French-speaking schools of the greater Montréal area in Canada. The schools were located in different socio-economic environments from well-privileged to under-privileged environments. Pupils were attributed a score of socio-economic status corresponding to the rating of their school from 1 (most privileged) to 10 (less privileged) by the Committee for the Management of Montreal School Tax (2018). Pupils were recruited through the reservation system of the Planétarium Rio Tinto Alcan, where the programming workshop took place. The Planétarium Rio Tinto Alcan is a public institution whose mission is to educate and inspire the general public about astronomy. It is part of Espace pour la vie (Space for Life), Canada’s largest natural science museum complex. All teachers who booked the programming workshop were invited to obtain parents’ consent and to participate in the study with their class. In total, 188 pupils participated in the study. From the initial sample eight pupils were excluded because they did not identify as male or female in the questionnaire. In addition, only data from participants who filled the questionnaire both before and after the workshop was included in the analysis.
The attrition rate was 2% (4/188). From the remaining sample of \( N = 176 \), outliers were removed based on the three inter-quartiles range rule multipliers. The outliers are believed to be measurement errors, for instance a participant that claims to be fully capable of writing code that can make a robot move but that subsequently claims to not be able to edit, find an error in the code, or predict the output of the code. Four cases were excluded based on that rule, resulting in a 2.2% rate of extreme data (4/176). The final sample included 172 pupils (94 girls and 78 boys).

**Ethical Considerations**

Information to teachers and parents emphasized that pupils would need less than 10 min to complete the Mastery Experiences in Programming Questionnaire, and that participating in the research was without risk and could even allow pupils to become aware of their own progress in programming and improve their self-efficacy beliefs for programming as a result of the workshop. The pupils were selected for participation in this study via purposeful sampling based on parents’ consent to participate. Pupils whose parents did not give their consent were not invited to fill out the questionnaire. However, they were still allowed to participate in the programming workshop at the Planétarium Rio Tinto Alcan without any prejudice. Ethics approval was obtained from the ethics committee (Comité interinstitutionel d’éthique de la recherche avec des êtres humains, Université du Québec à Montréal, Canada). Pupils were told that their class was participating in a scientific study aimed at improving programming workshops in science museums. They were invited to complete the Mastery Experiences in Programming Questionnaire before and after the activity if they so wished.

**Instrument—Mastery Experiences in Programming Questionnaire**

Bandura (2006) identifies four main sources of self-efficacy beliefs: (1) mastery experiences; (2) vicarious experiences; (3) verbal persuasion; and (4) psychological state. Although all four sources are useful in boosting self-efficacy, mastery experiences are the most powerful (Bandura, 1997). Thus, we are particularly interested in how a programming workshop in a science museum setting may impact mastery experiences, since it is the factor most likely affected by a hands-on learning activity. We are also interested in the appreciation of the workshop by the pupils and inquired about their enjoyment of the activity.

As Bandura prescribed, a self-efficacy scale should assess the perceived capability to produce given attainments (Bandura, 2006). The standard method of measuring academic self-efficacy is to present problem questions that are similar to actual problems students must solve. Students are then asked to estimate their confidence that they can solve each problem correctly (e.g. Bandura and Schunk, 1981). Thus, our instrument is inspired by the Computer Programming Self-Efficacy Scale for Computer Literacy Education (Tsai et al., 2019). We included in our questionnaire nine items related to the mastery experiences. Six items explore programming skills sub-scale (e.g. ‘I am able to test a program on a robot to verify that it works as planned.’) and three items explore the perseverance sub-scale related to programming challenges (e.g. “I am able to stay focused even when programming a robot is not going as well as I’d like it to.’’). In addition, one item regarding enjoyment (“I am able to enjoy programming a robot.”) was included to assess emotional state of learners. Pupils rated each item on a 7-point Likert format ranging from ‘Not at all able’ to ‘Definitely able’. We also included three items tapping pupils’ satisfaction towards group work (e.g. ‘I am satisfied with the way my teammates and I cooperated and shared the work during the activity.’) that were rated on a 7-point Likert format ranging from ‘Don’t agree at all’ to ‘Totally agree’. One item asked pupils to indicate their prior programming experience. Enjoyment, satisfaction in group work, and prior programming experience have the potential to greatly affect
the extent to which pupils gain mastery experiences during the workshop; thus, their scores are used to assess equivalence of girls’ and boy’s sub-samples before conducting gender comparisons. Finally, an item on general satisfaction asking participants to range their experience on a scale of 1 to 7, where 1 represents ‘Did not enjoy at all’ and 7 represents ‘Enjoyed very much’, was included in the questionnaire for the museum’s administrative purpose. The full questionnaire is available in English (translated) and French (original) versions in Supplementary Material section.

**Factor Structure of the Mastery Experiences in Programming Questionnaire**

Mastery Experiences in Programming Questionnaire (MEPQ) was tested and validated in its original French version. An exploratory factorial analysis using the principal component method and varimax rotation was carried out to examine the factor structure of the nine items questioning self-efficacy beliefs. Statistical analyses were performed using SPSS version 27.0 (SPSS Inc., Chicago, IL, USA). The number of factors to retain was determined based on construct validity (Scree test) and interpretability criteria. The resulting factors had eigenvalues of 4.98 and 1.43 and the factor loadings exceeded 0.30, showing minimal overlap among factors. The analysis used varimax rotation with Kaiser normalization and yielded two factors. The first factor (Q_1-Q_6) reflects confidence in accomplishing different programming tasks and was named ‘Programming Skills (PS)’. The second factor (Q_7-Q_8; Q_10) reflects the ability to persist despite challenges and was named ‘Perseverance when Programming (PP)’. The two factors explained 70.33% of questionnaire variance. The subscales’ reliability was calculated by Cronbach’s $\alpha$, which reached 0.93 for the programming skills sub-scale and 0.66 for the perseverance when programming sub-scale. Both values were considered satisfactory (Nunally, 1978). Although the perseverance when programming sub-scale would have ideally been greater than 0.70, a threshold of 0.60 can be considered satisfactory when a sub-scale included fewer items as is the case here. This limitation should be kept in mind when interpreting the results. Finally, according to the factor analysis, the ‘programming Skills’ and ‘Perseverance when Programming’ sub-scales were moderately related ($r = 0.37$).

**Workshop Overview**

This study was conducted according to a pre-post-test design using a paper-and-pencil Mastery Experiences in Programming Questionnaire (MEPQ) before and after a programming workshop. The programming activity, named The Aldebaran Project, is an initiative of the Planétarium Rio Tinto Alcan, in Canada, inviting pupils to learn how to program using LEGO® Mindstorms®. Upon arrival, teachers were asked to supervise pupils as they form small groups of two to four participants, depending on the size of their class and their preferences. During the 2-h workshop, pupils were encouraged to become budding scientists and engineers and to carry out activities that required them to solve problems, interact, and collaborate. Their objective was to build a base on the planet Mars using a LEGO® robot, an iPad®, and the Mindstorms® software.

The provided LEGO® EV3 robotics kits contain a robot (also known as a brick), regular LEGO® pieces, and three wheels that are already put together. MINDSTORMS® software allows pupils to download programming commands to make the robot move through an object-based programming environment that is tailored for middle grade. At the start of the workshop, the basic LEGO® EV3 pieces were already put together to make a robot, i.e. a simple three-wheeled rover. To fulfil their mission, pupils had to first learn how to use simple code in the MINDSTORM® software environment to move the robot. This requires choosing a movement programming block and setting the speed and number of wheels’ rotations. Once pupils understood how many rotations it takes for the robot to move specific
distances, they could alter the program to make the robot turn left and right. In a nutshell, the pupils learned to move, turn, or stop when an obstacle is detected. Thus, pupils were able to create road maps for the robot to travel and work on challenging tasks.

**Results**

The sample included 172 pupils (94 girls and 78 boys). Results in Table 1 show that there were no significant difference in girls’ and boys’ sub-samples in terms of age ($p = 0.14$), enjoyment of the workshop ($p = 0.61$), socio-economic score ($p = 0.81$), satisfaction towards teamwork ($p = 0.99$), first language (French vs. other) ($p = 0.59$), or prior programming experience (never/once vs. 2 times or more) ($p = 0.11$).

**H1**

Firstly, we wanted to explore gender differences in self-efficacy before the robotics workshop. We conducted an independent sample $t$-test between girls and boys on the two sub-scales of mastery experiences: Programming Skills (PS) and Perseverance when Programming (PP). There was a significant difference in scores for Programming Skills: $t(170) = 2.204, p < 0.05, d = 1.6$; $\bar{x}_{\text{girls}} = 3.8 \pm 0.2$; $\bar{x}_{\text{boys}} = 4.4 \pm 0.2$. No significant difference in scores for Perseverance when Programming was found: $t(174) = 0.513, p = 0.61$; $\bar{x}_{\text{girls}} = 5.9 \pm 0.1$; $\bar{x}_{\text{boys}} = 5.8 \pm 0.1$. Results (Table 2) show that before the programming workshop girls had lower self-efficacy beliefs regarding programming skills compared to boys, but their perseverance when programming appeared to be similar to that of their male peers.

**Table 1** Comparison of sub-samples of girls and boys on socio-demographic metrics and affective metrics of workshop experience

| Measure                      | Girls | Boys | Stat (df) | Value | p-value |
|------------------------------|-------|------|-----------|-------|---------|
| Age                          | 12.0  | 12.1 | $t(167)$  | 1.490 | $p = .14$ |
| Enjoyment of the workshop    | 6.5   | 6.6  | $t(169)$  | .513  | $p = .61$ |
| Underprivileged area score   | 5.8   | 5.7  | $t(170)$  | .486  | $p = .63$ |
| Satisfaction towards teamwork| 5.7   | 5.7  | $t(167)$  | .003  | $p = .99$ |
| First language (# French speakers) | 72/94 | 63/78 | $\chi^2(1, 171)$ | .286 | $p = .59$ |
| Prior experience (# novices) | 49/94 | 32/78 | $\chi^2(1, 170)$ | 2.533 | $p = .11$ |

*SD*, standard deviation; $\bar{x}$, mean; *Stat*, statistical test; *df*, degrees of freedom

**Table 2** Comparisons of group means and standard deviations for Mastery Experiences Scores of girls and boys before the workshop

|                  | Gender | N   | Mean | Std. deviation | Std. error mean |
|------------------|--------|-----|------|----------------|-----------------|
| **PS_Score_pretest** |        |     |      |                |                 |
| Girls            | 94     | 3.8 | 1.6  |                | .2              |
| Boys             | 78     | 4.3 | 1.6  |                | .2              |
| **PP_Score_pretest** |        |     |      |                |                 |
| Girls            | 94     | 5.9 | 1.1  |                | .1              |
| Boys             | 78     | 5.8 | 1.2  |                | .1              |

*PS*, Programming Skills; *PP*, Perseverance when Programming
H2

Then, we aimed to explore the effects of participating in the robotics workshop on pupils’ self-efficacy beliefs both generally (H2.1) and by gender (H2.2).

H2.1

A paired samples $t$-test was conducted on the two sub-scales of mastery experiences: PS and PP. There was a significant increase in Programming Skills score between the pretest and the post-test: $t(171) = 14.916, p < 0.001, d = 1.5; \bar{x}_{PS\ pretest} = 4.0 \pm 0.1; \bar{x}_{PS\ posttest} = 5.7 \pm 0.1$. There was also a significant increase in Perseverance when Programming score between the pretest and the post-test, although of smaller magnitude: $t(171) = 5.435, p < 0.001, d = 1.1; \bar{x}_{PP\ pretest} = 5.9 \pm 0.1; \bar{x}_{PP\ posttest} = 6.3 \pm 0.1$. Results (Table 3) show that pupils’ self-efficacy beliefs for programming related to mastery experiences are on average greater after the workshop.

H2.2

Then, we wanted to explore the gender differences in developing self-efficacy beliefs related to mastery experiences for programming during the workshop. A one-way ANCOVA was conducted to determine a statistically significant difference between girls’ and boy’s post-test scores on the two dimensions of mastery experiences, controlling for pretest scores: Programming Skills (Figs. 1 and 2) and Perseverance when Programming (Fig. 3).

Contrary to the pretest, there is no significant effect of gender on PS scores following the workshop after controlling for pretest scores ($F(1, 172) = 0.212, p = 0.65$). As was the case before the workshop, no significant difference in post-test scores for PP was found after controlling for pretest scores ($F(1, 172) = 0.041, p = 0.84$). Results indicate that after the workshop there were no more differences between girls’ and boys’ self-efficacy beliefs related to mastery experiences (Table 4).

Discussion

With a sample of 10–14-year-old pupils, the current study investigated the potential effects of a science museum programming workshop on mastery experiences, the most crucial source of self-efficacy beliefs, with a specific focus on girls.

As expected, results show a significant gender difference for mastery experiences related to programming skills before the workshop (H1). Boys reported higher self-efficacy beliefs related to their

| Table 3 | Comparisons of group means and standard deviations for Mastery Experiences Scores of all pupils before and after the workshop |
|---------|---------------------------------------------------------------|
|         | Mean | N  | Std. deviation | Std. error mean |
| Before the workshop | PS_Score_pretest | 4.0 | 172 | 1.7 | .1 |
|         | PS_Score_posttest | 5.7 | 172 | 1.0 | .1 |
| After the workshop | PP_Score_pretest | 5.9 | 172 | 1.1 | .1 |
|         | PP_Score_posttest | 6.3 | 172 | 0.8 | .1 |

PS, Programming Skills; PP, Perseverance when Programming
programming skills than girls. However, contrary to our hypothesis, there is no significant gender differences for mastery experiences related to perseverance when programming. Thus, our findings are partially consistent with results in computer science education: women, more than men, believe they have little natural ability in programming (Beyer, 2014). The absence of gender difference related to perseverance when programming concurs with previous work that also reported no evidence of gender differences in mastery experiences related to programming in undergraduates (Ramalingam, & Wiedenbeck, 1998; Lent et al., 1991; Smith, 2001). The reason for this rather contradictory result is possibly that previous studies have explored gender differences in mastery experiences as a whole and did not break down in sub-scales of programming skills and perseverance when programming.

Moreover, the present study reveals that participation in a short 2-h programming workshop relates to a significant increase of pupils’ self-efficacy beliefs. Boys and girls reported higher self-efficacy
beliefs related to programming skills and to perseverance when programming and effects were of large magnitude. Martin et al. (2016), Dohn (2013), and Jarvis and Pell (2002) found that museum visits of only a few hours can significantly impact children’s beliefs in their capabilities. In this sense, encouraging teachers to include more non-formal science activities to their planning might be an interesting avenue to allow pupils to develop their self-efficacy beliefs in regard to mastery experiences. This is not so surprising, considering that in recent years, science museums have made efforts to make learning intrinsically motivated, promote physical interactivity, and allow students to be the driving force behind their exploration of science (Allen, 2004). Indeed, pupils’ participation in such programming activities that sustain involvement should offer them opportunities to control and manipulate the user interface, which is crucial to developing programming skills and strong self-efficacy beliefs.

We were surprised to find that the initial gender gap in self-efficacy beliefs had been closed after the workshop. Boys generally have more positive experiences with STEM activities than girls, irrespective of experimental condition (e.g. Alexander et al., 2012; Kessels & Hannover, 2008; Hoffmann, 2002). Accordingly, we had predicted that boy’s self-efficacy beliefs would have increased more than girls’ self-efficacy beliefs after the programming workshop, and that they should have kept their “lead”. Although both boys’ and girls’ self-efficacy beliefs increase after participation, the increase of girls’ self-efficacy beliefs related to programming skills was more important. In fact, the initial superiority of boys’ beliefs is no longer observed after the workshop. A simple explanation could be that since girls has lower scores at pretest, they just had more room for improvement. Another explanation is more speculative and relates to the composition of team work. In our study, 85 out of the 94 girls choose to work in single-sex groups. Participation of girls in single-sex teams may have offered them more occasions to control and manipulate the user interface, a crucial factor in developing programming and computational thinking skills. In the study by Wieselmann et al. (2017), interviews with elementary school girls revealed that

| Table 4 | Comparisons of group means and standard deviations for Mastery Experiences Scores of girls and boys after the workshop |
|------------------------|------------------------|------------------------|------------------------|
| Gender | N | Mean | Std. deviation | Std. error mean |
| PS_Posttest | | | | |
| Girls | 91 | 5.7 | 1.0 | .1 |
| Boys | 77 | 5.8 | 1.0 | .1 |
| PP_Posttest | | | | |
| Girls | 91 | 6.3 | .7 | .1 |
| Boys | 77 | 6.3 | .9 | .1 |

PS, Programming Skills; PP, Perseverance when Programming
they describe their male peers as easily distracted compared to the focused behaviour they see as more typical of females. Others show that female-majority groups provide different experiences for girls as compared to female-minority or sex-parity groups. For instance, Monereo et al. (2013) found that groups of secondary school pupils with more girls report better social atmosphere and interaction. Along the same line, Dasgupta et al. (2015) report that forming groups with high proportions of women in male-dominated fields such as computer science is an effective way to keep women engaged and motivated. In sum, there seem to be several instances where all-girl groups were more effective than mixed-sex groups (Bennett et al., 2010). Silfver (2019) suggests that, in order to address gender stereotypes, museums should carefully think about how workshops are organized so that “students have a fair chance to collaborate on equal terms.” (p. 153). Finally, we were unsuccessful at exploring gender differences in self-efficacy beliefs in regard to perseverance, as a high proportion of participants had a close to maximum score on this sub-scale and it makes discrimination among the pupils challenging.

Some limitations of our research must be mentioned. The first is related to the instrument. We might have been confronted with a slight ceiling effect in the post-test data where many pupils obtained scores close to the highest possible value on our Likert scale. This limitation is especially noticeable on the Perseverance when Programming (PP) scale. The second limitation is the age range of the participants. Our sample includes pupils aged 10–14 years old, so our conclusions cannot be extended to older girls. Witherspoon et al. (2016) found that younger girls are more heavily involved in programming while older high school girls are generally less involved, even after controlling for prior programming experiences. Thus, our results showing that a 2-h workshop has, at least in the short term, momentarily closed the gender gap in self-efficacy beliefs for programming might be partly driven by our younger female pupils. Lastly, although our results point towards a positive effect of single-sex group work on girls’ development of self-efficacy beliefs, further data collection would be needed to determine exactly how single-sex group work affects self-efficacy beliefs for programming, in particular the use of a well-matched control group.

**Conclusion**

Our results show that after a 2-h programming workshop in a science museum, gender differences in self-efficacy for programming initially observed narrowed and even disappeared. Encouraging female participation in hands-on programming activities, even when those are of short duration, could be a particularly beneficial strategy to encourage girls’ participation in computer science and to offer them exposure to mastery experiences. However, it remains unclear whether there would be lasting effect of a short workshop and if we would obtain similar findings with an older sample. Further experimental investigations are also needed to determine if single-sex setting was a determining factor in developing girls’ self-efficacy beliefs for programming. Single-sex settings may allow girls to experience STEM without being overly exposed to strategies more frequently used by boys, such as dominance, competition, and suppression (Hoffmann, 2002). While the literature on women’s experience in many STEM fields (physics, mathematics, biology, etc.) is quite abundant, few studies have explored how the gender composition of small group work affects younger girls’ participation in programming. One interesting avenue would be to explore whether or not single-sex small group work is beneficial for girls’ participation in programming activities and the development of their self-efficacy for programming.
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Declarations

Conflict of Interest  The authors declare no competing interests.

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