NEWSLETTER

Can Programming Really Promote Individual Development of Children? A Meta-analysis on 28 Experimental and Quasi-experimental Studies

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AS a basic skill of children facing the future, adapting to the future, and transforming the future, programming has continuously received attention from all walks of life. Scholars have carried out a great deal of experimental and quasi-experimental research, but the results of the research differ. To respond to the topic "whether children's programming promotes children's individual development", a study from *Journal of East China Normal University (Education Science Edition)* adopted a meta-analysis method to conduct empirical research on the influence of programming on individual development by reviewing 28 independent studies and 74 effect sizes that can be used for analysis. The research results were evaluated to summarize the degree of influence of programming on the individual development of children. In addition, the study further analyzed the differences in the influence of programming on the individual development of children by different stages, programming styles, sample sizes, and experimental cycles, to obtain scientific and reasonable conclusions and provide a feasible reference for the subsequent progress in children's programming education research and practice.

The important findings of the study are as follows:

- In this study, the combined effect size of the overall impact of programming on children's individual development is SMD = 0.61 > 0.5, which shows that programming has a positive effect on children's individual development.
- This study further measured the specific effects of programming on children's individual development from three dimensions: cognition, behavior and emotion.

First, at the cognitive level, the combined effect size of programming on individual children is (SMD = 0.86, $p < 0.001$), reaching a statistically significant level, indicating that programming can significantly and actively promote the cognitive development of students. Specifically, programming influences mathematical thinking (SMD = 2.68, $p < 0.001$), academic achievement (SMD = 0.61, $p < 0.001$), knowledge transfer (SMD = 0.82, $p < 0.001$) and computational thinking (SMD = 0.50, $p < 0.001$). The impacts reach a significant level.

Second, at the behavioral level, the combined effect size of programming on children's individual development is (SMD = 0.34, $p < 0.001$), indicating that programming has a significant intermediate effect on children's behavior development, specifically, in pair ranking ability (SMD = 0.65, $p < 0.001$), classification planning (SMD = 0.31, $p < 0.05$), problem solving (SMD = 0.25, $p < 0.05$) and collaborative innovation (SMD = 0.40, $p < 0.01$) The impacts are of significant levels.

Finally, at the emotional level, the combined effect size of programming on children's individual development is (SMD = 0.31, $p < 0.001$), indicating that programming has a significant intermediate effect on children's emotional development. Specifically, programming has significant impacts on learning interest (SMD = 0.51, $p < 0.01$) and children's self-efficacy (SMD = 0.22, $p < 0.05$), and the impacts on children's learning motivation (SMD = 0.19, $p > 0.05$) and learning participation (SMD = 0.20, $p > 0.05$) are not significant.

Overall, programming has significant positive effects on children's cognitive, behavioral, and emotional development, and it has the most prominent effect on cognitive development.

- From the perspective of different learning stages, there is no significant difference between the group effects ($Chi^2 = 2.67$, $p > 0.05$) of children's programming in preschools, elementary schools and middle schools. The effects of programming on the individual development of students at different school stages are ranked in order of the combined effect size: middle school (SMD = 0.77, $p < 0.001$), preschool (SMD = 0.56, $p < 0.001$) and elementary school (SMD = 0.52, $p < 0.001$)).
- From the perspective of different experimental cycles, there are significant differences in the impact of programming experiment cycles of different lengths ($Chi^2 = 24.68$, $p < 0.001$) on the individual development of children. Specifically, the short-term experiment had the highest combined effect size (SMD = 0.43, $p < 0.001$), followed by the long-term experiment (SMD = 0.26, $p < 0.001$), and the mid-term experiment had the lowest combined effect size (SMD = 0.24, $p < 0.001$).
- From the perspective of different sample sizes, the intergroup effect size shows $Chi^2 = 23.53$, $p < 0.001$, reaching a significant level, indicating that there are significant differences in the influence of programming on the individual development of large, medium, and

small-scale of student sample. Specifically, the small-scale combined effect size (SMD = 0.41, $p < 0.001$) is higher than that of the medium-scale (SMD = 0.37, $p < 0.001$) and higher than the large-scale combined effect size (SMD = 0.17, $p < 0.001$). This shows that small-scale programming activities have a more significant impact on children's individual development than medium-scale and large-scale programming activities. Moreover, there is a negative correlation between the sample size and the effect. As the sample size increases, the effect gradually decreases. This finding can provide a reference for the design and development of subsequent programming activities.

- From the perspective of different programming forms, the intergroup effect size shows $Chi^2 = 32.72$, $p < 0.001$, reaching a significant level, indicating that there are significant differences in the role of different programming forms in promoting the individual development of children. Specifically, unplugged programming has the highest combined effect size (SMD = 1.47, $p < 0.001$), followed by LOGO programming (SMD = 0.78, $p < 0.05$), other programming forms (SMD = 0.41, $p < 0.001$), and Scratch (SMD = 0.23, $p < 0.001$) with the lowest combined effect size, which indicates that unplugged programming is significantly better than other programming forms in promoting the individual development of children. However, there is a possibility that this is caused by the differences among users in different groups.

In summary, the analysis results affirm the importance of programming to children's growth and its positive role in promoting individual development. However, research results also shows that programming education will present different effects when facing different learners and learning situations. Therefore, programming teaching practice should not be carried out blindly. Instead, it should be designed and planned scientifically and reasonably according to the different elements of the teaching system.

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