An innovative approach to a new pedagogical teaching concept for PABO students in STEM

Nardie Fanchamps, Renée-Claire Belting, Paul Hennissen, Stefan Mandos, Juliette Passariello-Jansen, Renato Rogosic, Krist Shingjiergji, Bart Beaumont, Paulo LeBrun

"Learning is experience, everything else is just information" **- Albert Einstein**

Introduction

- STEM knowledge and digital practice are crucial skills to navigate the 21st century (Slangen, 2009).
- Increasing emphasis on Science, Technology, Engineering, & Mathematics (STEM) education to prepare children in primary education for current societal challenges (Bybee, 2013).
- Lack of attuned pedagogy
  - knowledge- and attitude gap of students.
  - Students are deprived of seeing good examples in practice (Şenyiğit et al., 2021).

RQ: *Which inquiry-based learning environment used by PABO students is most effective in stimulating knowledge and attitude development towards the preparation of elementary school students in STEM subjects?*

Fig 1. *Flui.Go highly visual ICT learning kit.*

Fig 2. *Conventional Science experiment box.*

Study I - Primary school pupils

Methods

Design:

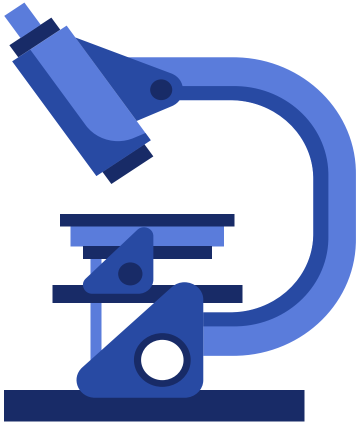
- Explorative study
- Pre-test-post-test design

Sample:

- Students (n=60; 40% males, 60% females)
- aged 11-12 (grade 7 & 8)
- Primary school in South Holland

Measures:

- Children’s Attitude toward Technology Scale (CATS) questionnaire
- Fascination for Science
- Value of Science
- Science and Physics Concepts quiz
- Qualitative: observable behavior



Results - Quantitative

Table 1. Children's Attitudes toward Technology Scale (CATS).

Variable	Pre-test CATS (26 items)				Post-test CATS (26 items)			
	M	*SD*	*Range*	*Mdn*	*M*	*SD*	*Range*	*Mdn*
Flui.Go (n = 16)	2.75	0.13	0.54 - 2.96	2.77	2.80	0.18	2.54-3.23	2.81
Science box (n = 16)	2.63	0.26	2.19 - 3.31	2.60	2.74	0.24	2.50-3.42	2.70
Control group (n = 18)	2.68	0.27	2.12 - 3.38	2.69	2.63	0.16	2.35-2.92	2.67

Note. M = average; SD = standard deviation; range = spread in measurement; Mdn = median.

- Average score (M) in post-test higher for students in experimental environments than control group → indicative of a more positive attitude toward technology.
- Magnitude of effect size:
  - **Flui.Go kit group:** significantly different mean value with measurable large effect size in comparison to the control group.
  - **Commercial science box group**: no statistically significant difference to control group, nor between Flui.Go and commercial science box.

Results – Qualitative

Observations

- Students involved in either one of the two experimental groups were enthusiastic and demonstrated a higher drive to learn about STEM.

- Usage of the Flui.Go kit had several benefits over the commercially available science boxes, comparing both experimental environments.

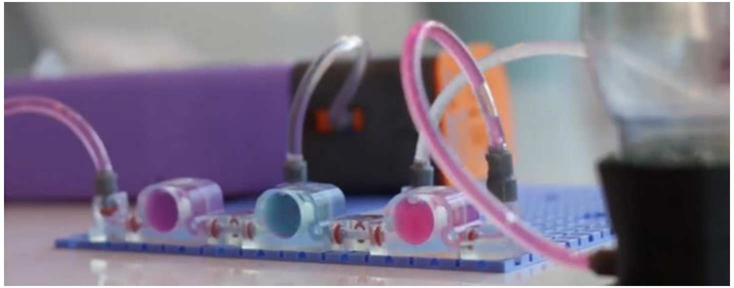
  - **Engagement**
  - **Creativity**
  - **Understanding of Complex Processes**
  - **Benefits for educators**

Conclusion

- Evidence for more positive attitude towards STEM through the application of highly visual ICT learning environments in which play-based learning takes place.

- Increase in the learning of underlying STEM concepts can be demonstrated compared to more traditional approaches.

- Observed benefits for both teachers and primary school pupils.



Study II - PABO Students

Methods

Design:

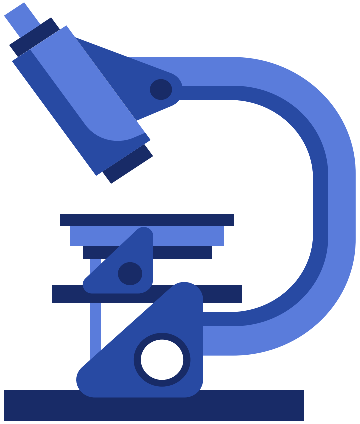
- Explorative study
- Pre-test-post-test design

Sample:

- PABO students (N=45; Flui.Go *n*=16, Science Box *n*=17, Simulation *n*=12)
- Aged 19-26 (second year)
- Fontys Hogescholen & Zuyd Hogeschool Applied Science University > de Nieuwste Pabo (dNP)

Measures:

- TOSRA (Test of Science Related Attitudes)
- Conceptual Knowledge Test



Results II - Quantitative

Table 2. Test Of Science Related Attitudes (TOSRA – 70 items).

Variable	Pre-test CIS (10 items)				Post-test CIS (10 items)			
	M	*SD*	*Range*	*Mdn*	*M*	*SD*	*Range*	*Mdn*
Flui.Go (*n* = 16)	3.28	0.24	2.90 - 3.70	3.20	3.28	0.24	2.90 - 3.70	3.20
Science box (*n* = 17)	3.10	0.25	2.70 - 3.50	3.20	3.10	0.25	2.70 - 3.50	3.20
Simulation (*n* = 12)	3.14	0.27	2.70 - 3.40	3.20	3.14	0.27	2.70 - 3.40	3.20

Note. M = average; SD = standard deviation; range = spread in measurement; Mdn = median.

Career Interest in Science (CIS):

- Above average growth on comparison between all three groups. (F = 4.560, *p* = 0.016), effect size Eta square of 17.8%.
- Significant difference due to application of Flui.Go as a high visual ICT STEM learning environment in a direct comparison with applying a simulation (post-hoc analysis, *p* = 0.016).
- No significant difference between Flui.Go and a science box, or between a simulation and a science box.

Results - Quantitative

Conceptual knowledge test: significant

Table 3. Conceptual Knowledge Test (CKT – 25 items).

Variable	Pre-test Density (5 items)				Post-test Density (5 items)			
	M	*SD*	*Range*	*Mdn*	*M*	*SD*	*Range*	*Mdn*
Flui.Go (*n* = 16)	0.91	0.10	0.86 - 0.97	1.00	0.88	0.20	0.77 - 0.98	0.80
Science box (*n* = 17)	0.88	0.16	0.80 - 0.96	1.00	0.89	0.14	0.82 - 0.97	0.80
Simulation (*n* = 12)	0.80	0.28	0.62 - 0.98	1.00	0.84	0.20	0.56 - 0.84	0.80

Note. M = average; SD = standard deviation; range = spread in measurement; Mdn = median.

Density:

- Above-average growth on the averages apparent in a comparison between pre-measurement - post-measurement across all three groups.
- Found significant differences (F = 4.311, p = 0.020) with an effect size Eta square of 17.0%.
- Further post-hoc analysis reveals that the significance difference arose from application of Flui.Go as a high visual ICT STEM learning environment in a direct comparison with applying a simulation (p = 0.049), and that the significant difference also arose from application of a science box in a comparison with applying a simulation (p = 0.024).
- The comparison between Flui.Go and a science box produced no significant difference.

Results - Quantitative

Conceptual knowledge test: significant

Table 4. Conceptual Knowledge Test (CKT – 25 items).

Variable	Pre-test PH-Value (5 items)				Post-test PH-Value (5 items)			
	M	*SD*	*Range*	*Mdn*	*M*	*SD*	*Range*	*Mdn*
Flui.Go (*n* = 16)	0.50	0.28	0.35 - 0.65	0.60	0.57	0.29	0.42 - 0.73	0.60
Science box (*n* = 17)	0.52	0.27	0.38 - 0.66	0.60	0.66	0.23	0.54 - 0.78	0.60
Simulation (*n* = 12)	0.58	0.25	0.43 - 0.74	0.60	0.35	0.19	0.23 - 0.47	0.60

Note. M = average; SD = standard deviation; range = spread in measurement; Mdn = median.

PH Value:

- Above-average growth on the averages visible in a comparison between pre-measurement - post-measurement in all three groups.
- Found significant differences ($F = 5.709$, $p = 0.006$) with an effect size Eta square of 21.4%. Further post-hoc analysis reveals that the significance difference arose from application of a science box in a direct comparison with applying a simulation ($p = 0.005$), and a nearly significant difference ($p = 0.054$) also arose from application of Flui.Go as a high visual ICT STEM learning environment in a comparison with applying a simulation.
- The comparison between Flui.Go and a science box produced no significant difference.

Results – Qualitative

Broad:

- Initially reduced intrinsic motivation to explore underlying concepts (knowledge component).

- Students have little awareness of developing their own skills (exploration, fine motor skills, cooperation, etc.). Translation to own learning environment is triggered especially by questions of guidance.

- Conscious self-assessment of abilities is limited. This is evidenced by the fact that students have not asked to apply this in their internship class. What also played a role in the outcomes is that students were able to see the other research groups at the time of working with different interventions. This may have had an effect on student motivation and the results as such determined through the questionnaire survey.

Results – Qualitative

Specific:

- During the first session with students, we noticed that the Flui.Go environment attracted the most attention from the students.

- Because each student was able to see all three environments, they also saw that interesting material was used within Flui.Go. The students sitting at the computer were less distracted.

- At first students seemed a bit confused about how to use the Flui.Go kit, they struggled to take initiative compared to the other two learning environments (simulation and science box). With practice, students became accustomed to the Flui.Go kit and greater motivation and engagement were observed. Enthusiasm among participating students.

- High engagement with Flui.GO. In particular, attitude aspect "will to achieve" (persevering and energetic to get started) was evident Students who had used Flui.Go before were motivated to repeat experiments and change the setup.

- We observed more enthusiasm in the FluiGo groups; they worked better as a team, distributed the task, asked each other questions and were eager to try the experiment again.

- As for the simulation, students did not really enjoy the lesson but were focused on the task. As for the science boxes, students finished the experiment much earlier (something positive as they learn the concepts of experiments) but were not motivated to repeat experiments or lost more focus.

+ 2 additional questions in report

Conclusion

- Analysis showed that all three learning environments tested provide both broad and specific added value for the development of Pabo students in the STEM domain.
- That students developed a positive attitude towards science and technology and that, depending on the subject and chosen content concept, a clear growth in knowledge and level can be observed.
- In this regard, the hands-on approach seems to be more effective than the purely digital learning environment that does not use concrete materials.
- In addition to increased interest, motivation, perception, involvement and enthusiasm for science and physics, the interventions selected in this project offer a clear added value for conceptual knowledge development and for matching the specific developmental needs of students.
- It can also be argued that the educational / pedagogical possibilities can be broadened by offering students an adaptive and differentiated learning environment that meets their learning needs and that technology can offer an important, facilitating role in this.
- Especially the latter is an important observation regarding the provision of adaptive education and the desired pedagogical and educational optimization in which student choice and opportunities provide a framework for the offering teacher.
- Therefore, the findings from this Comenius project obtained as such will provide a basis for further curriculum optimization.

General Discussion

Conclusion

- All three learning environments used provide both broad and specific added value for the development of Pabo students in the STEM domain, that they develop a positive attitude towards science and technology and that, depending on the subject and chosen content concept, a clear growth in knowledge and level can be observed.

- In this regard, the hands-on approach seems to be more effective than the purely digital learning environment that does not use concrete materials.

- In addition to increased interest, motivation, perception, involvement and enthusiasm for science and physics, the interventions selected in this project offer a clear added value for conceptual knowledge development and for matching the specific developmental needs of students.

- It can also be argued that the educational / pedagogical possibilities can be broadened by offering students an adaptive and differentiated learning environment that meets their learning needs and that technology can offer an important, facilitating role in this.

- Especially the latter is an important observation regarding the provision of adaptive education and the desired pedagogical and educational optimization in which student choice and opportunities provide a framework for the offering teacher. Therefore, the findings from this Comenius project obtained as such will provide a basis for further curriculum optimization.

Q&A

Live Demonstration

References

Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities.

Senyigit, Ç., Önder, F., & Silay, I. (2021). An Inquiry-Based Learning Approach for Effective Concept Teaching. ie: Inquiry in Education, vol. 13(1), 10.

Slangen, L (2009). *Techniek, leren door doen. Didactiek en bronnen voor de pabo*. Baarn, Netherlands: HB Uitgevers.

Sumida, M. (2015). Kids science academy: Talent development in STEM from the early childhood years. In *Science Education in East Asia* (pp. 269-295). Springer, Cham.

White, D. W. (2014). "What is STEM education and why is it important?," *Florida Association of Teacher Educators Journal*, vol. 1, no. 14, pp. 1-8.