
INQUIRY BASED CHEMISTRY ACTIVITIES IN THE NON-FORMAL EDUCATIONAL SETTING FOR GIFTED STUDENTS

Luka Vinko, Miha Slapničar, Janez Vogrinc and Iztok Devetak

University of Ljubljana, Faculty of Education, Slovenia

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PROJECT RESEARCH GROUP



Prof. Dr. Iztok Devetak
National coordinator



Assist. Prof. Dr. Miha
Slapničar



Prof. Dr. Janez Vogrinc



Luka Ribič, PhD student



Luka Vinko, PhD
student



Prof. Dr. Vesna Ferik Savec



GIFTED STUDENTS IN CHEMISTRY

- Same aspects of giftedness in science/chemistry (Taber, 2010):
 - Continued scientific and technological progress depends upon **sufficient numbers of young people selecting scientific courses in post compulsory education and aspiring to enter science related professions.**
 - Gifted students **appreciate being challenged** in their learning and often recognise that work that does not challenge them does not help them learn and consequently is not valuable/relevant to their education (in terms of everyday life, societal needs, personal interests, career aspirations, or even just because it is clearly useful in achieving intrinsic learning goals).
 - **Highly-able/gifted students** are likely to become the researchers, innovators, academic scholars, and inspirational teachers of the future.
 - Types of modern chemistry courses:
 - **Context-based courses**
 - **Inquiry approach** – lab-work; problem solving; HOCS; NOS; Science-Technology-Society links; working in groups; self-regulated learning.

NATIONAL PERSPECTIVES - ACTIVITIES FOR GIFTED STUDENTS IN SLOVENIA

1. Chemistry competitions organised by ZOTKS
2. Elective courses in chemistry - lower and upper secondary school
3. Primary and secondary school students' research activities in collaboration with universities and institutes
4. Activities in KemikUm Centre at the UL PEF



Chemistry solves crimes



Chemistry is experimenting



Molecular gastronomy



KemikUm drives on methane

IBL – INQUIRY BASED LEARNING

- ... is a **student-centred method** (Reid & Ali, 2020) "in which learning is driven by a process of inquiry" (Khan & O'Rourke, 2004, p.1).
- Students have **positive attitudes towards inquiry activities** in science classes and therefore show more interest in learning about science (Eltanahy & Forawi, 2019).
- IBL can **positively influence gifted students'** chemistry learning (Jurišević & Devetak, 2018).
- IBL does **not have a significant positive impact** on the development of secondary school students' chemistry knowledge and skills **unless it is guided** to some extent by the teacher (Szalaya, Tóth & Borbás, 2021).
- It is reasonable to assume that individual interest in learning chemistry may influence how students perceive learning and how IBL activities influence students' **situational interest** and **attitudes towards** the IBL approach and activities conducted in the chemistry laboratory.

Eltanahy, M., & Forawi, S. (2019). Science teachers' and students' perceptions of the implementation of inquiry-based learning instruction in a middle school in Dubai. *Journal of Education*, 199(1), 13–23. Doi: 10.1177/0022057419835

Jurišević, M., & Devetak, I. (2018). Learning science through PROFILES: are the any benefits for gifted students in elementary school? In K. Taber, M. Sumida, & L. McClure (Eds.). *Teaching gifted learners in STEM subjects: developing talent in science, technology, engineering and mathematics* (pp. 125–144). London: Routledge.

Khan, P., & O'Rourke, K. (2004). *Guide to curriculum design:enquiry-based learning*, Imaginative Curriculum Network, University of Manchester, Higher Education Academy, http://www.ceebl.manchester.ac.uk/resources/guides/kahn_2004.pdf (accessed 18 January, 2022).

Reid, N., & Ali, A. A. (2020). *Making sense of learning. A research-based approach. Evidence to guide policy and practice, with anemphasis on secondary stages*. Cham: Springer.

Reid, N., & Ali, A. A. (2020). *Making sense of learning. A research-based approach. Evidence to guide policy and practice, with anemphasis on secondary stages*. Cham: Springer.

Szalay, L., Tóth, Z., & Borbás, R. (2021). Teaching of experimental design skills: Results from a longitudinal study. *Chemistry Education Research and Practice*, 22(4), 1054–1073. doi: rg/10.1039/D0RP00338G

DiSSI MODULES FOR THE GIFTED STUDENTS IN CHEMISTRY - INQUIRY-BASED LAB ACTIVITIES

1. Forensics Science
2. Environmental Chemistry – Hydrosphere pollution
3. Molecular aspects of modern gastronomy
4. Biologically active substances in pepper
5. Green Chemistry of the future
6. Chemistry of honey



INTRODUCTION

Purpose of the study:

- To illustrate the development of learning modules and their adaptations for teaching chemistry in the context of the IBL approach in non-formal educational setting.
- To find out whether the original DiSSI modules and the adapted modules have significantly different effects on students' situational interest in chemistry learning and on their views about IBL.

Gifted students

Identified as academically gifted

Self-evaluated as gifted for chemistry



RESEARCH QUESTIONS

- Are there any significant differences between gifted and non-gifted students in their situational interest after the non-adapted and adapted DiSSI module application?
- Are there any significant differences between students, who perceive themselves as gifted or non-gifted for chemistry, in their situational interest after the non-adapted and adapted DiSSI module application?
- Are there any significant differences between gifted students in their situational interest whether they participated in DiSSI module application before or after its adaptation?
- Are there any significant differences between non-gifted students in their situational interest whether they participated in DiSSI module application before or after its adaptation?
- Are there any significant differences between students, who perceive themselves as gifted for chemistry, in their situational interest whether they participated in DiSSI module application before or after its adaptation?
- Are there any significant differences between students, who perceive themselves as non-gifted for chemistry, in their situational interest whether they participated in DiSSI module application before or after its adaptation?
- Are there any significant differences between gifted and non-gifted students in how they perceive IBL whether they participated in DiSSI module application before or after its adaptation?
- Are there any significant differences between students, who perceive themselves as non-gifted for chemistry, in how they perceive IBL whether they participated in DiSSI module application before or after its adaptation?

METHOD - SAMPLE

79 girls; 55 boys; 2 other

Σ 136 students from 11 lower secondary schools

8th grade: 35

9th grade: 101

Gifted: 67 yes; 69 no

Module adaptations

Before: 68

After: 68

Group		Average grade in chemistry
Gifted	Yes	4.81 (SD = .58)
	No	4.09 (SD = .82)
Gifted for chemistry	Yes	4.76 (SD = .55)
	No	4.13 (SD = .88)
Module adaptations	Yes	4.28 (SD = .76)
	No	4.60 (SD = .81)



METHOD - INSTRUMENTS

Pre-workshop questionnaire:

- Demographics (age, gender, grade level, giftedness, giftedness for chemistry, their final grade in chemistry from the previous school year),
- individual interest (5 items),
- interest in science career (7 items),
- self-concept (6 items),
- autonomous motivation (5 items),
- controlled motivation (5 items).

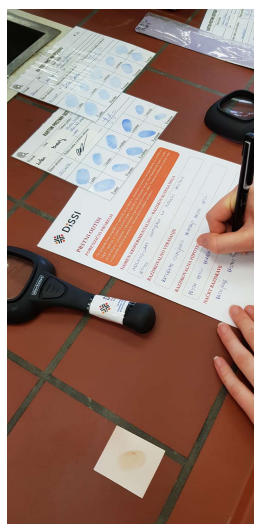
Post-workshop questionnaire:

- Situational interest (10 items),
- implementation of IBL in the chemistry classroom at their school (5 items),
- attitude toward IBL after the workshop (7 items).



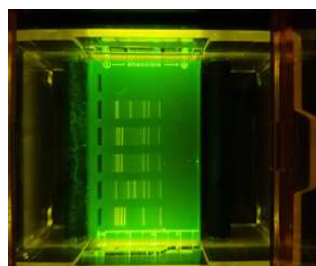
METHOD – RESEARCH DESIGN

Workshop development:



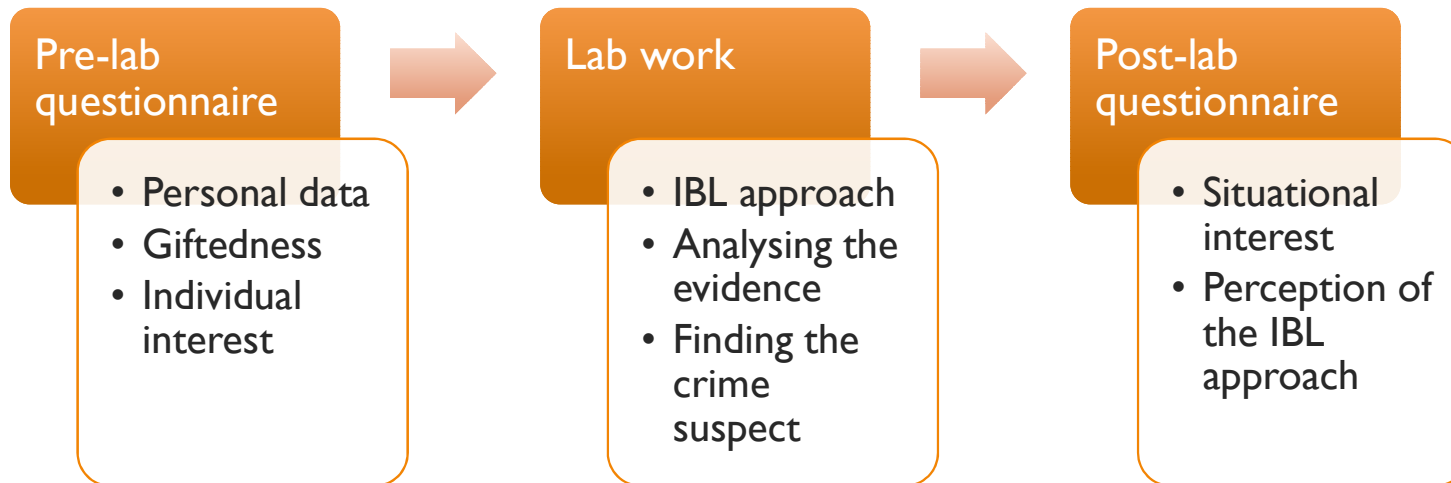
I. Preverjanje električne prevodnosti raztopin

Slika poskusa	Potek dela po stopenjah
	<ul style="list-style-type: none"> V dve 50 gL čali nalij približno 20 gL destilirane vode. V prvo dodaj eno zgornjo snovi A, v drugo pa eno spodnjo snovi B. Premešaj, da se snovi raztopita.
	<ul style="list-style-type: none"> Prigraji aparaturo za preverjanje prevodnosti pripravljenih raztopin. En vodnik s krokodilčkom pripravi na pozitivno stran baterije. Drugi vodnik na enem delu s krokodilčkom pripravi na negativno stran baterije, z drugim pa na krajšo žico diode. Na daljšo žico diode s krokodilčkom pripravi še preostali vodnik.
	<ul style="list-style-type: none"> Preveri prevodnost raztopin. Pomoči nepovezana dela vodnikov v eno ločen raztopin. Pazi, da se konici vodnikov pri tem ne dotakneta.
	<ul style="list-style-type: none"> Previdni vodnika pomolži v drugo raztopino, ju speni z destilirano vodo.
	<ul style="list-style-type: none"> Zapiši opažanja.



METHOD – RESEARCH DESIGN

Workshop implementation:



RESULTS

Workshop analysis and evaluation – statistical analysis

Non-adapted module:

- Difference in **situational interest** between **gifted** and **non-gifted** students.

	\bar{R}	U	p
Situational interest	Yes 34.80	515.0	.867
	No 33.96		

- Difference in **situational interest** between **gifted (for chemistry)** and **non-gifted (for chemistry)** students.

	\bar{R}	U	p
Situational interest	Yes 39.72	339.5	.007
	No 26.57		

Effect size = 0.11 ($r = 0.32$)

Adapted module:

- Difference in **situational interest** between **gifted** and **non-gifted** students.

	\bar{R}	U	p
Situational interest	Yes 36.85	373.0	.271
	No 31.29		

- Difference in **situational interest** between **gifted (for chemistry)** and **non-gifted (for chemistry)** students.

	\bar{R}	U	p
Situational interest	Yes 37.71	379.0	.123
	No 30.24		

RESULTS

Workshop analysis and evaluation – statistical analysis

Gifted students:

- Difference in **situational interest** between students who participated in **adapted** and **non-adapted module**.

	\bar{R}	U	p
Situational interest	Yes 36.65	357.0	.228
	No 30.65		

Gifted students for chemistry:

- Difference in **situational interest** between students who participated in **adapted** and **non-adapted module**.

	\bar{R}	U	p
Situational interest	Yes 33.71	475.0	.816
	No 32.59		

Non-gifted students:

- Difference in **situational interest** between students who participated in **adapted** and **non-adapted module**.

	\bar{R}	U	p
Situational interest	Yes 35.21	530.5	.904
	No 34.60		

Non-gifted students for chemistry:

- Difference in **situational interest** between students who participated in **adapted** and **non-adapted module**.

	\bar{R}	U	p
Situational interest	Yes 37.68	423.0	.101
	No 29.67		

RESULTS

Workshop analysis and evaluation – statistical analysis

Non-adapted module:

- Difference in **IBL perception** between **gifted** and **non-gifted** students.

	\bar{R}	U	p
IBL perception	Yes 34.40	523.5	.954
	No 34.69		

- Difference in **IBL perception** between **gifted (for chemistry)** and **non-gifted (for chemistry)** students.

	\bar{R}	U	p
IBL perception	Yes 40.18	320.5	.003
	No 25.87		

Effect size = 0.13 ($r = 0.36$)

Adapted module:

- Difference in **IBL perception** between **gifted** and **non-gifted** students.

	\bar{R}	U	p
IBL perception	Yes 37.67	444.5	.341
	No 32.88		

- Difference in **IBL perception** between **gifted (for chemistry)** and **non-gifted (for chemistry)** students.

	\bar{R}	U	p
IBL perception	Yes 38.25	448.5	.215
	No 32.18		

RESULTS

Workshop analysis and evaluation – statistical analysis

Non-adapted module:

- Difference in **IBL perception** between **gifted** and **non-gifted students**.

	\bar{R}	U	p
IBL perception phases	Yes 35.81	470.5	.456
	No 32.10		

- Difference in **IBL perception** between **gifted (for chemistry)** and **non-gifted (for chemistry) students**.

	\bar{R}	U	p
IBL perception phases	Yes 40.80	295.0	.001
	No 24.93		

Effect size = 0.16 ($r = 0.40$)

Adapted module:

- Difference in **IBL perception** between **gifted** and **non-gifted students**.

	\bar{R}	U	p
IBL perception phases	Yes 39.39	376.5	.110
	No 31.37		

- Difference in **IBL perception** between **gifted (for chemistry)** and **non-gifted (for chemistry) students**.

	\bar{R}	U	p
IBL perception phases	Yes 37.60	439.5	.224
	No 31.72		

CONCLUSIONS

- Significant differences were shown between students, who perceive themselves as gifted or non-gifted for chemistry, in their situational interest after the non-adapted DiSSI module application.
- Students who perceive themselves as gifted for chemistry showed higher interest for the non-adapted DiSSI module.
- **DiSSI activity** implementing IBL approach is **more adequate for gifted students**, because they find it more interesting.
- After the module adaptations there were no significant differences between gifted and non-gifted students and also between students who perceive themselves as gifted and those who don't, in their situational interest.



CONCLUSIONS

- ~~■ There is no significant difference between gifted students in their situational interest whether they participated before or after DiSSI module adaptations.~~
- ~~■ The gifted who participated in the adapted module showed more interest towards the workshop activities.~~
- ~~■ There is no significant difference between non-gifted students in their situational interest whether they participated before or after DiSSI module adaptations.~~
- ~~■ The non-gifted who participated in the adapted module showed more interest towards the workshop activities.~~
- **Module adaptations had a positive effect on both gifted and non-gifted students' interest for the DiSSI module.**
- **Module adaptations had a positive effect on students who don't perceive themselves as gifted for chemistry and their interest for the DiSSI module.**
- **Module adaptations had no effect on students who perceive themselves as gifted for chemistry and their interest for the DiSSI module.**



CONCLUSIONS

- Module adaptations had a positive effect on gifted students` attitude towards IBL and IBL phases.
- Module adaptations had a positive effect on students who don`t perceive themselves as gifted for chemistry and their attitude towards IBL and IBL phases.
- Module adaptations had no effect on students who perceive themselves as gifted for chemistry and their attitude towards IBL and IBL phases.



Disclaimer:

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