EUROPEAN SCIENCE EDUCATION RESEARCH ASSOCIATION

ESERA 2025 Copenhagen

Development of an Instrument to Identify Alternative Conceptions about the Urinary System in High School and University Students

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Problem Statement

- ✓ Physiology is highly conceptual and difficult to learn and teach (Colthorpe et al., 2018).
- ✓ Students face difficulties due to a lack of integration and causal reasoning (Michael, 2007).
- ✓ Physiology is often studied through rote memorization, affecting retention (González et al., 2008).
- ✓ There are several persistent alternative conceptions about the human body (Versteeg et al., 2020).
- ✓ The Chilean school curriculum addresses the urinary system only briefly (MINEDUC, 2015; 2016; 2019).
- ✓ Alternative conceptions that students bring with them hinder university learning (Wandresee et al., 1994).

It is necessary to know beforehand which alternative conceptions are present in our students in order to develop learning strategies that help overcome them (Cliff, 2006).

Hypothesis

An appropriate instrument to identify alternative conceptions about the urinary system in high school and university students should meet validity and reliability criteria that support its use as a diagnostic tool in educational contexts.

General Objective

To develop a valid and reliable instrument to identify the alternative conceptions of high school and university students regarding relevant concepts of the urinary system.

Specific Objectives:

- To identify and define the scientific concepts and their alternative conceptions about the urinary system to be included in the assessment instrument.

- To design and validate (by experts, content, construct, and criterion) the instrument that identifies alternative conceptions in high school and university students.

- To evaluate the capacity of the instrument to discriminate between different levels of knowledge.

Type of study

The study follows an exploratory approach. The first part is descriptive, outlining the steps taken to obtain the final product (the instrument). The second part is quantitative, as the instrument collects quantitative information from a non-probabilistic convenience sample of students.

Methodological Design

Step 1: Conceptualization of knowledge about the urinary system

Step 2: Item creation

Step 3: Variable operationalization

Step 4: Validity and reliability (steps detailed in table)

Criterion	N° participants	Main Characteristics
Content validity	3	University-level physiology professors
Construct validity	3	University-level didactics professors
Criterion validity	3	High school biology teachers
Reliability	185	Pilots with students from different educational levels

Reliability testing: Cronbach's Alpha from pilot responses

Statistical test: Kruskal-Wallis for non-normally distributed samples

Step 1: Conceptualization of urinary system knowledge

Semi-structured group interviews with 18 students from schools in the Valparaíso Region.

Question	Answer	Times that the answer appeared
Which other body system do you think is directly connected to the urinary system?	Digestive System	4
	Immune system	2
	Circulatory System	5
	Nervous system	2

Example: Interview to students from a School in Viña del Mar

Line 44, Interviewer: “With which other systems do you think the urinary system might be connected?”

Line 47: Student 1: “Digestive”

Line 48: Student 2: “Immune, digestive, and that’s it.”

Step 2: Item creation and expert review

- ✓ 10 open ended questions were developed
- ✓ Reviewed by experts: university physiology professors, university didactics professors, high school biology teachers.

Version	Statement
1	Luis is a lively child, and after a day full of play, he ran home at full speed to go to the bathroom. While relieving himself, he noticed that his urine was darker than usual and that the amount he passed was quite reduced. This alarmed him, and he ran to tell his mother. What would you have answered to explain the amount and color of his urine?
2	Luis has noticed that, on different days of the week and even within the same day, his urine can change in amount and color without a clear reason. How would you explain the changes in urine color and quantity in a healthy person?

Step 2: Item creation and expert review

Pilot 1: Questionnaire reviewed with 6 final-year high school students.

Question	Scientific Concept	Alternative conception (AC)	Number of students with the AC
1	Trajectory of molecules from mouth to urine	From intestines directly to bladder	6
2	Relevance of Kidney in blood pressure regulation	Toxins and other compounds accumulate in blood obstructing blood flow	3
3	Benefit of drinking urine in the absence of water	Urine is beneficial because it hydrates	4
4	Presence of protein in urine	Proteins are found in urine when we eat an excess	6
5	Presence of kidney stones	Stones come from the food we eat	1
6	Changes of color and volume of urine	Color and volume changes when the kidney is not healthy	6
7	Presence of glucose in urine	Glucose is always found in urine	6
8	Presence of bacteria in bladder	Bacteria come from what we eat	2
9	Definition of secretion	Movement of substances from kidney cells to the blood	6
10	Type of particles that can be filtrated	Negative particles cannot be filtered independent of the size	5

Step 3: Variable operationalization

Development of a rubric for each item with Likert-scale response evaluation.

ITEM	Statement	No response	Nonsensical answer	Alternative conception (AC)	Mix of AC and SC	Scientifically accepted concept (SC)
05	The following picture shows stones (calcium and/or other compound deposits) that were removed from the kidneys or urinary tracts of living people. Could you explain how it is possible to find stones in the urinary system? 	In their response, they write “I don’t know” or “I don’t understand,” or simply do not respond.	Gives an answer that paraphrases the question or that is unrelated to it Example: A specific symptom is the appearance of blood in the urine and pain when urinating; with imaging equipment, it is possible to determine the presence of kidney stones.	Considers that the stones (or calculi) come from the digestive system or considers that they form in the blood. Example: Because when you are a child you might eat dirt, and those things stay inside your body.	Considers that they form in the kidney due to a diet high in those ions or in the kidney due to excess glucose (sugar) or sodium chloride (salt). Example: Formation occurs when consuming things that contain other minerals that react, or Stones in the urinary system are created due to excessive salt consumption, which, when it cannot be properly eliminated, calcifies and forms stones.	Considers that they form in the kidney due to genetic alterations that manifest when there is an accumulation of ions and a lack of water. Example: Poor nutrition and hydration.

Step 4: Reliability

Pilot 2

Level	Institution	Nº students
3rd year university	Biology Teaching, University in the Metropolitan Region	8
3rd year university	Biomedical Science Engineering, University in the Valparaíso Region	30
2nd year university	Nutrition and Dietetics, University in the Valparaíso Region	9
11th year of school	School in the Metropolitan Region	46
11th year of school	School in the Valparaiso Region	32
11th year of school	School in the Valparaiso Region	31
9th year of school	School in the Valparaiso Region	29
TOTAL		185

Cronbach's Alpha = 0.87

Case Processing Summary

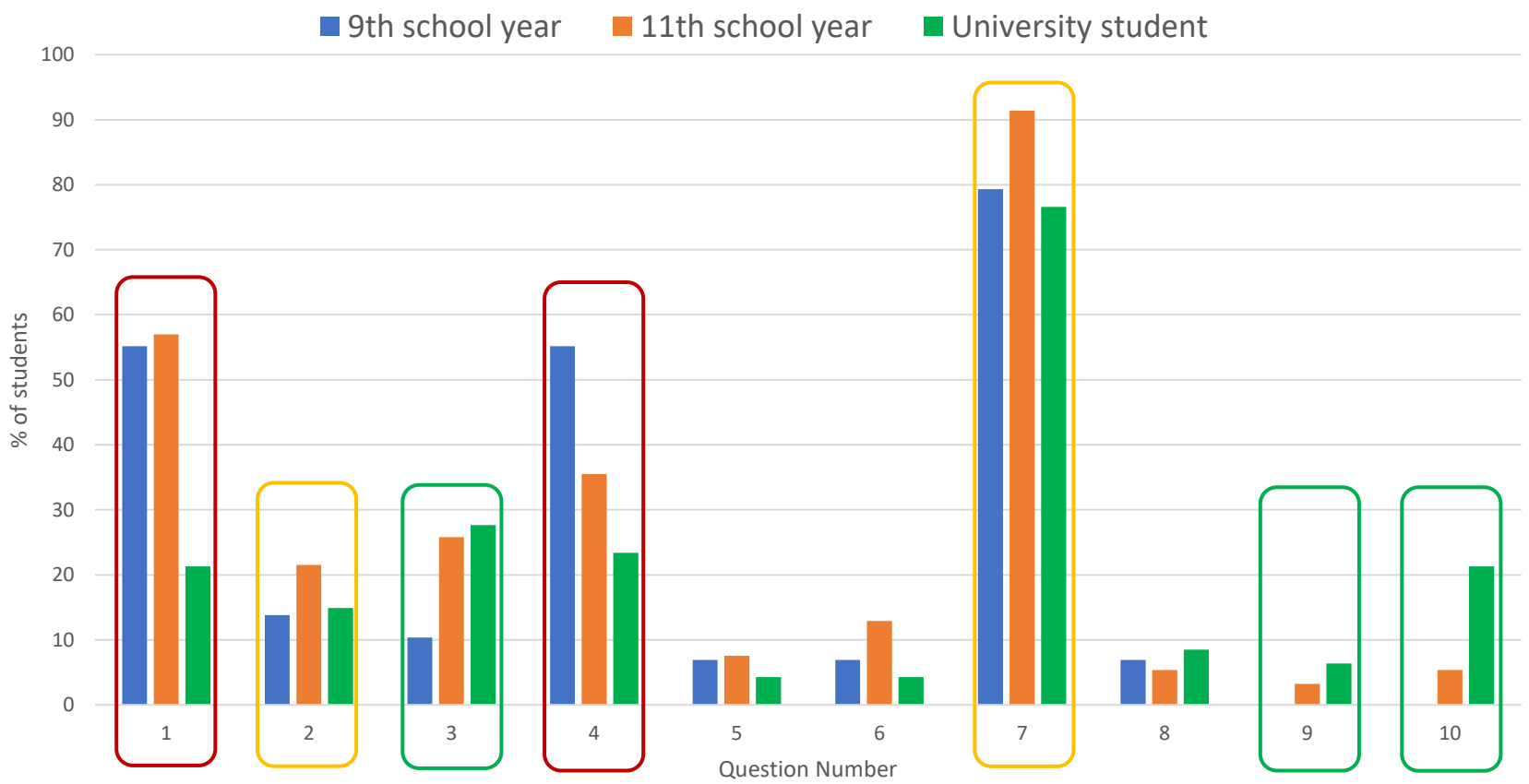
		N	%
Cases	Valid	185	100.0
	Excluded[a]	0	.0
	Total	185	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.869	.874	10

RESULTS



1. **Pathway of molecules from the mouth to the urine**
2. **Importance of the kidney in regulating blood pressure**
3. **Usefulness of drinking urine in the absence of water**
4. **Presence of proteins in urine**
5. **Presence of kidney stones**
6. **Changes in the color and volume of urine**
7. **Presence of glucose in urine**
8. **Presence of bacteria in the bladder**
9. **Definition of secretion**
10. **Types of particles that can be filtered**

Figure 1 – Comparison between university and high school students who responded with the alternative conception.

RESULTS

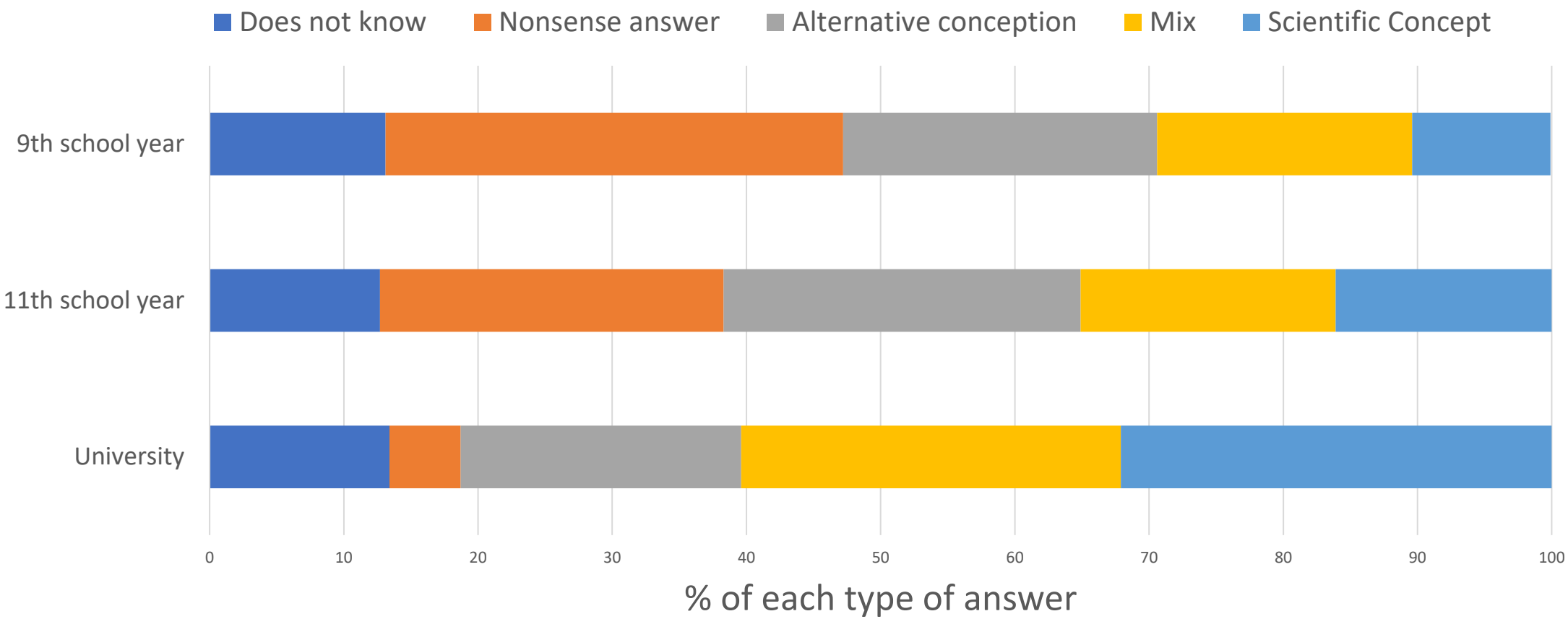
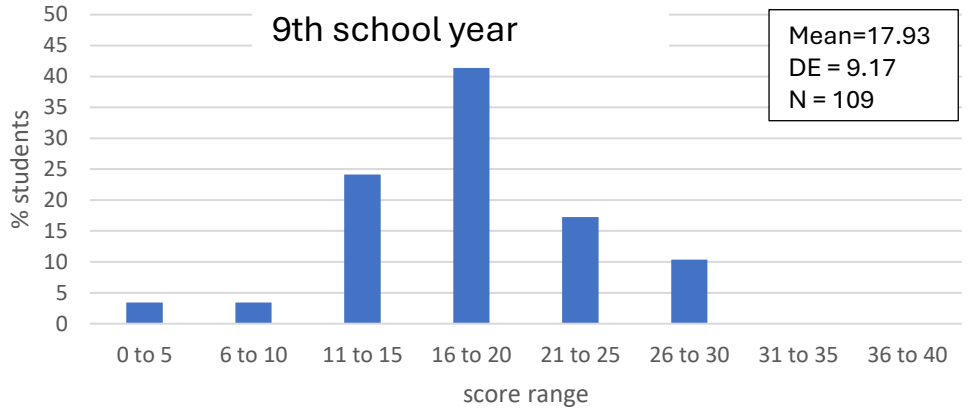
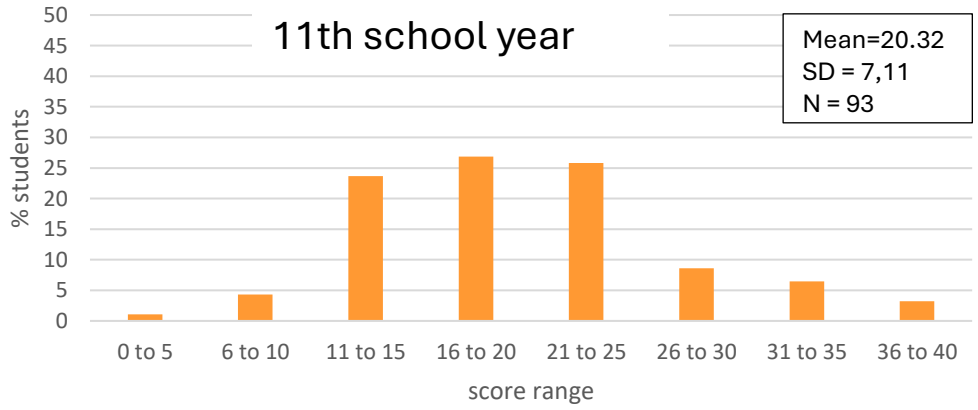


Figure 2 – Percentage comparison of different response types between university students and 3rd- and 1st-year high school students.

RESULTS

- University students had the highest scores.
- Eleventh-year high school students showed the greatest dispersion.





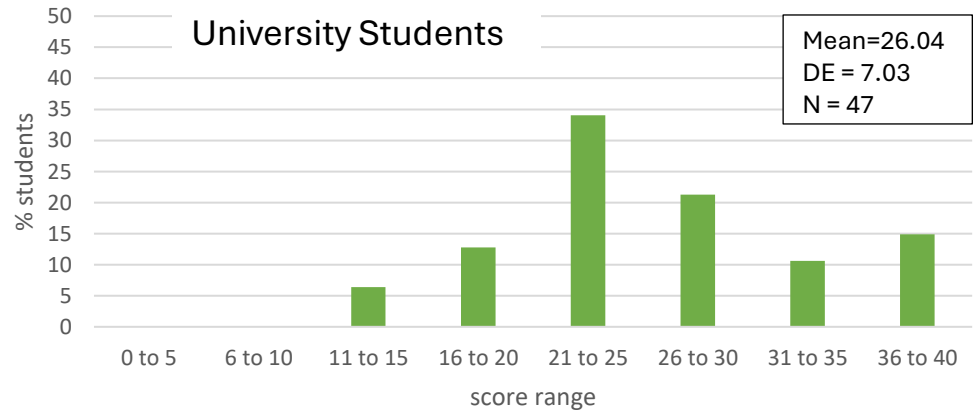


Figure 3 – Histograms of total questionnaire scores by educational level.

RESULTS

Statistical tests: Kruskal-Wallis and Dunn's test with Bonferroni correction ($p < 0.05$).

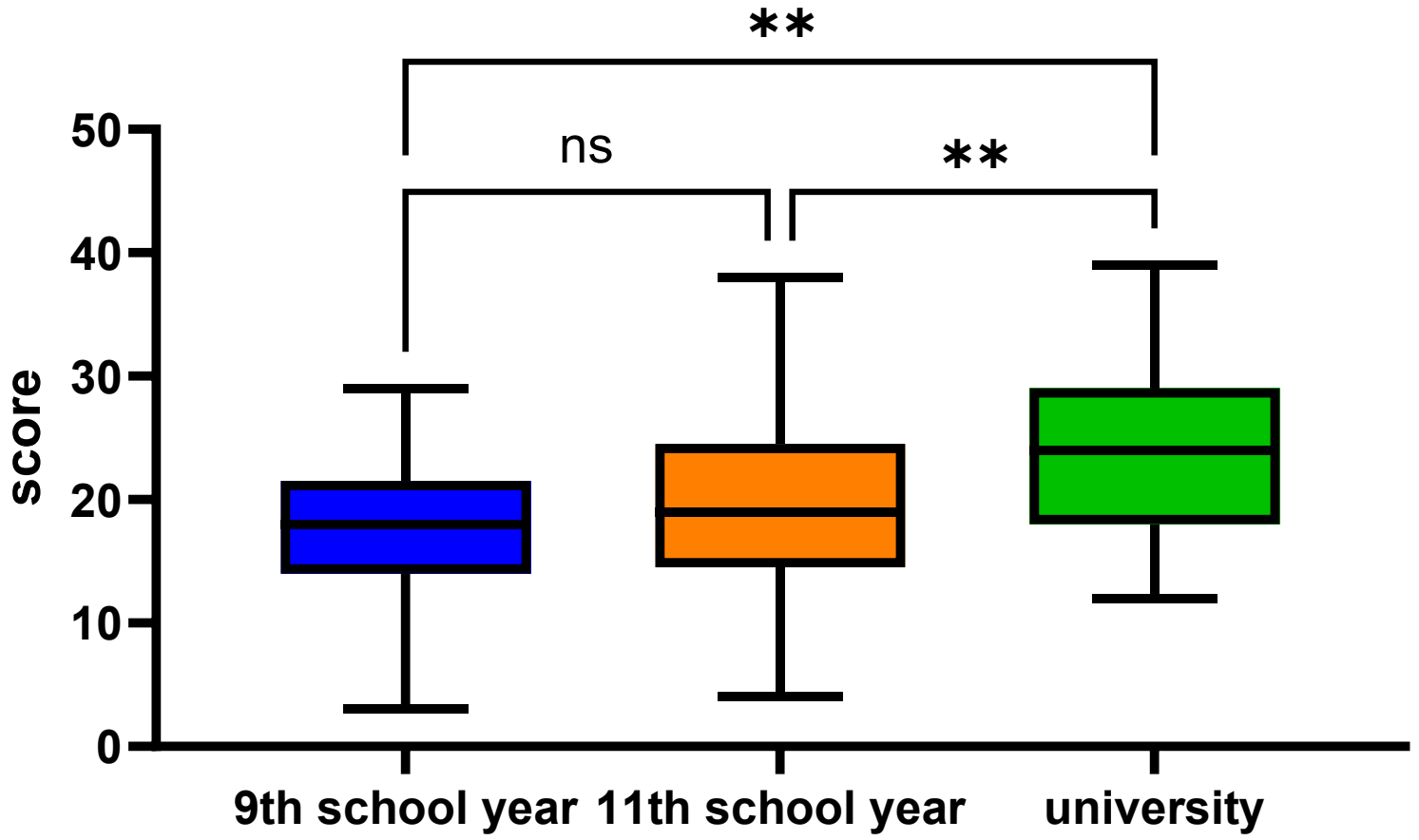


Figure 4 – Boxplot distribution of questionnaire scores for 9th-year school, 11th-year school, and university students.

Discussion and Conclusions

- The developed instrument meets the need to identify alternative conceptions in students, consistent with recent educational research.
- Unlike previous studies, this research focuses on the urinary system, a rarely explored topic in educational studies.
- Alternative conceptions were detected in both high school and university students, more frequently in the former.
- The use of open-ended questions is an advantage over more structured tools, as it allows identification of emerging alternative conceptions.
- This work provides a validated instrument and empirical evidence on alternative conceptions in the urinary system, offering a useful tool for educators and researchers interested in promoting conceptual change in this area of biology.

Thank you for your attention!

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Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
VAR00001	17.4378	64.454	.641	.472	.852
VAR00002	17.5405	62.652	.639	.460	.852
VAR00003	17.1568	68.926	.487	.295	.864
VAR00004	17.5892	63.591	.577	.356	.857
VAR00005	17.6919	64.910	.561	.355	.858
VAR00010	17.6432	61.644	.589	.377	.857
VAR00009	18.2541	64.854	.610	.445	.855
VAR00008	17.4649	62.359	.586	.399	.857
VAR00007	17.8811	67.823	.674	.486	.855
VAR00006	16.7676	63.277	.575	.368	.858