

Adherence to International Anatomical Terminology by a Government-implemented High School Biology Science Education Curriculum

Uso de la Terminología Anatómica Internacional en el Currículo Nacional de Biología en Enseñanza Media

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SUMMARY: Chilean science education curriculum is standardized and issued by the Ministry of Education (MINEDUC). This study contributes to science education analyzing a government implemented high school biology curriculum and its adherence to the Federative International Programme for Anatomical Terminology (FIPAT). The purpose of this study was to assess the use of International anatomical terminology (IAT) in Chilean national biology education programs. The sample consisted of biology programs for 9th to 12th grades obtained from the MINEDUC website, in force since 2009. An analysis of terms used in MINEDUC high school programs (9th to 12th grade) was carried out. Terms were identified using Atlas.ti text analysis software. Subsequently, the identified terms were tabulated as follows: frequency, Latin term, Spanish translation, use of the term according to FIPAT and type of error. Our results showed that 11.43 % of the terminology used in the high school biology curriculum did not adhere to the IAT in FIPAT. 11th grade's biology education curriculum showed the highest use of FIPAT terminology and also the same grade showed the highest prevalence of misused terms. These results can serve as an important basic resource for the revision and standardization of terminology used in biomedical fields. Collaboration between anatomists, biologists and high school teachers is a requirement necessary to make changes in the curricula in order to improve the use of IAT in teacher training and in Biology and Natural sciences classes.

KEY WORDS: Anatomical techniques; Science education; High school students; Biology teaching

INTRODUCTION

A sustained approach to communication skills training will help to equip our students to communicate easily with many aspects of modern society (Evans, 2013). In any discipline, the use of clear and specific language is essential for the exchange of knowledge and the reproduction of findings and results generated (Gómez *et al.*, 2012). Particularly in morphology topics, terminology has evolved over time, making it the subject of considerable controversy and disagreement, hindering scientific communication (Whitmore, 1999; Kachlik *et al.*, 2008; Martin *et al.*, 2009; Burdan *et al.*, 2016; Strzelec *et al.*, 2017). Therefore, several attempts have been made on multiple occasions to unify the terminology in a universal language (Algieri *et al.*, 2013). The use of International Anatomical Terminology (IAT) emerges as the most contemporary aim for the unification

of associated vocabulary in morphological sciences (Algieri *et al.*; Burdan *et al.*; Strzelec *et al.*).

Interest in unifying anatomical, embryological and histological terms is explained as if it is only one code, highly defined and with a descriptive character exists; it could lead to an easier learning-teaching process in the mentioned area. In addition to, it helps to avoid misunderstandings in scientific communication in the same geographical zone and also in other places of the world (Algieri *et al.*).

Linguistic variations in morphology.

The use of language in applied morphological sciences causes terminological variations that transgress the

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principle of univocity of scientific language (Araujo, 2015). Univocity means that for each concept there is a linked term constituting a lexical-semantic linguistic mechanism in which the technicalities used have a monosemic value. Within anatomical language variations, emphasis is first placed on eponymy, which includes terms referring to names of persons or places which are used to designate names of concrete units such as cities or diseases and specifically in the area of anatomy, the names of structures (Algieri *et al.*; Araujo; Burdan *et al.*). Synonymy is another type of variation that occurs when several terms point at the same concept (Algieri *et al.*; Díaz Rojo, 2001; Jiménez Gutiérrez, 2009; Salgado & Trujillo, 2010) and is understood to be strongly associated with eponymy, given that different names are often used to identify the same structure (Araujo). A third variation is known as polysemy, where a plurality of meanings exists linked to a word or term (Araujo). Finally, homonymy is the phonic and graphic similarity between two terms which have different meanings (Araujo). There is another kind of variation in terminology, which occurs when in some countries or translations of anatomical writings, assign different names to structures or elements during the transcription process, which generates that a term is named in different ways according to different places (Algieri *et al.*).

The above mentioned variations are typical of the scientific language and are highly present in morphology, generating controversies and disagreements among specialists in this area (Algieri *et al.*; Araujo; Díaz Rojo; Jimenez; Salgado & Trujillo; Acuña *et al.*, 2007). Even more, this miscommunication and ambiguity can cause problems during the process of diagnosis and treatments, and also, in the teaching –learning process of anatomy (Strzelec *et al.*). But in the case of eponyms its origin is not recent, its apogee was in the XVI and XVII centuries during the scientific revolution, but its oldest records are placed before Christ (Algieri *et al.*; Cruz *et al.*, 2010; Araujo; Burdan *et al.*).

Unification and use of international terminology in morphology.

To avoid variations in terminology associated with morphology, in 1895, efforts began to unify the language with the development of the *Nomina Anatomica* of Basel, with Latin as the official language, using simple and brief characters to form structured terms which suppress eponyms (Algieri *et al.*; Díaz Rojo; Jiménez Gutiérrez; Salgado & Trujillo; Araujo). Years later, these lists were updated, until in 1989 the creation of the Federative International Committee of Anatomical Terminology (FICAT) would mark an important moment for achieving

universalization of the anatomical language. In 1998 members of FICAT published a listing which they called IAT. This was a list of Latin terms and their English translation, and was made up of 7583 anatomical terms (Algieri *et al.*).

Despite the efforts made in past years for the unification of anatomical terminology, it is necessary to achieve an actual universalization of terms based on the correct use by specialists and professionals linked to anatomy who are responsible for stimulating its knowledge (Algieri *et al.*). This context highlights the role of the Ibero-Latin American Symposiums of Terminology (SILAT), created by the Pan American Association of Anatomy in 2009. Its purpose is to unify denominations of structures in the region, as to achieve a common scientific language, facilitating learning and communication among professionals. This is achieved through the study, analysis, translation, dissemination and promotion of International Anatomical Terminology from the International Federation of Anatomist Associations (IFAA) (Losardo *et al.*, 2015). This work by SILAT places a new objective on the horizon which is to transcend International Terminology into university teaching programs and health and science institutions around the world to stimulate the application and correct use of this terminology (Losardo *et al.*, 2010, 2015). This can be achieved through a joint effort between SILAT, scientific societies, universities and ministries of education and health in each country to ensure that these results have an impact in the field of research, teaching and medical practice.

Use of international terminology in schools and vocational training processes.

In Chile, Ministry of Education (MINEDUC) considers that the use of correct terminology in science is important. This is shown in its “2016 preliminary orientation for preparation of school textbooks for natural sciences education” under the item of Content Management, which notes that both the study text and the didactic teaching guide “should define and rigorously use concepts, principles, laws and terms accepted by the scientific community, which must be up-to-date and validated, and correspond to University levels” (MINSAL, 2015). These considerations are present in basic aspects of form and content of textbooks participating in the bidding process, but performance level and other aspects are unknown. In addition, no studies are reported that account for the current situation in terms of describing correct terminology use associated with anatomy in basic programs and/or educational resources given by the ministry of education (textbooks, standardized tests, guides, among other school support elements).

MATERIAL AND METHOD

In the first stage, curricular programs for 9th to 12th grades were obtained from the MINEDUC website, in force since 2009 (Ministry of Education of Chile, 2017). An analysis of terms used in MINEDUC high school programs (9th to 12th grade) was carried out. Terms were identified

using Atlas.ti text analysis software (V8 Windows Scientific Software Development GmbH, Berlin, Germany). Subsequently, the identified terms were tabulated as follows: frequency, Latin term, Spanish translation, use of the term according to Federative International Programme for Anatomical Terminology (FIPAT) (Federative International Programme for Anatomical Terminology, 2017) and type of error (Table I).

Table I. Identification of terms used in study programs from 9th to 12th grade (MINEDUC). Example of some terms used in 10th grade program (Unit 2).

Unit 2: Structure and function of living beings: Hormones and human reproduction/ 10 th grade study program			International terminology (FIPAT)			
Term	Frequency	Term classification	Latin terms	Spanish translation	Use of the term	Error type
Hormone	19	E3.0.0.5.0.0.47	<i>Hormonum</i>	Hormona	Correct	-
Blood	7	A12.0.00.009	<i>Haema; sanguis</i>	Sangre	Correct	-
Ovary	6	H3.07.01.1.00001	<i>Ovarium</i>	Ovario	Correct	-
Uterus	6	H3.07.01.3.00001	<i>Uterus</i>	Útero	Correct	-
Cell	5	H1.00.01.00001	<i>Cellula</i>	Célula	Correct	-
Reproductive system	5	H3.07.00.0.00001	<i>Systemata genitalia</i>	Sistema genital	Incorrect	Synonymy
Testicles	2	H3.07.02.1.00001	<i>Testis; Orchis</i>	Testículo	Correct	-

Example of some terms used in 10th grade program (Unit 2).

Abbreviation: FIPAT, Federative International Programme for Anatomical Terminology; MINEDUC, Ministry of Education of Chile.

RESULTS

Use of international terminology in high school curricula.

Revision of the 9th to 12th grade programs reported that 88.57 % of used terms are used under FIPAT considerations, while 11.43 % of the terms correspond to linguistic variations which are not on the official list provided by FIPAT (Table II).

Regarding to terms that present linguistic variations, 93.75 % correspond to synonyms, while 6.25 % correspond to eponyms.

Use of international terminology according to year and unit.

Individual program analysis showed that 11th grade reports the greatest number of morphological terms and has the greatest number of linguistic variations in units: Nervous system (18.18 %); Homeostasis and internal regulation (20 %); Nervous Response (4.54 %), (Table II). On the other hand, units that did not show linguistic variations correspond to Evolution (Unit 4, eleventh grade) and Expression and manipulation of genetic material (Unit 1, 12th grade) (Table III).

Table II. Use of international anatomical terminology in study curriculum from 9th to 12th grade (MINEDUC).

	Total of terms in secondary educational level	%
Terms used according to FIPAT	124	88,57
Terms not used according to FIPAT	16	11,43
Total of used terms	140	100

Abbreviation: FIPAT, Federative International Programme for Anatomical Terminology; MINEDUC, Ministry of Education of Chile.

Table III. Use of international anatomical terminology by unit in study curriculum from 9th to 12th grade (MINEDUC).

LEVEL	UNIT	Total of used terms in IAT/IET/IHT	Correct terms	Incorrect terms	Synonymy	Eponymy	% of incorrect terms
Ninth grade	Unit 1: Structure and function of living beings: Structure and function of the cell	27	24	3	3	-	11.11
	Unit 1: Structure and function of living beings: Genetic and cell reproduction	22	22	-	-	-	0
Tenth grade	Unit 2: Structure and function of living beings: Hormones and human reproduction	25	24	1	1	-	4
Eleventh grade	Unit 1: Homeostasis and internal regulation	15	12	3	3	-	20
	Unit 2: Nervous system	22	18	4	3	1	18.18
	Unit 3: Nervous response	44	42	2	-	-	4.54
	Unit 4: Evolution	3	3	-	-	-	0
Twelfth grade	Unit 1: Expression and manipulation of genetic material	8	8	-	-	-	0
	Unit 2: Immune system: Structure and function	17	14	3	3	-	17.65
	Unit 3: Immune system: Illnesses and treatments	4	1	3	3	-	75

Abbreviations: IAT: International anatomy terminology; IET: International embryologic terminology; IHT: International histologic terminology; MINEDUC, Ministry of Education of Chile.

Finally, units which did not present morphological terms corresponded to (i) Organisms, environment and their interactions: Matter and energy flows in the ecosystem (Unit 2, 9th grade); (ii) Organisms, environment and their interactions: Dynamics of populations and biological communities (Unit 3, 10th grade); (iii) Environmental issues (Unit 4, 12th grade).

DISCUSSION

International morphology terminology in high school education.

Analysis on international terminology used in high

school curricula report that not all terms are used under the international terminology standards established by FIPAT (11.43 %). The greatest number of errors is concentrated in eleventh and twelfth grade units. Results discordant to those reported by Park & Park (2005), who after analyzing 7 high school biology textbooks and purchasing them with the IAT, determined that concordance of high school biology terms with the IAT was $50.3 \pm 2.7 \%$, whereas with official biological terminology it was significantly higher ($89.8 \pm 1.6 \%$). The most remarkable differences were found among terms that describe reproductive system. The units reporting the greatest number of errors are those referring to knowledge and comprehension of organism structures and system functions.

It is expected that textbook revisions referring to these units may contain a greater number of errors in terminology, given

the presence of a greater number of structures and terms used. Therefore, future research should be oriented to the analysis of school texts or teacher and/or student support texts.

The highest percentages of reported errors in the curricula refer to synonyms (93.75 %). This is due to several existing names to designate the same structure. Synonyms seem to not be only a present problem in curricula because even in the same international terminology of the FIPAT, there are up to 3 terms to designate a single structure. This is the case of Myelencephalon (A14.1.03.003), a term that in the eleventh grade program appears under the name of Bulb, the third of 3 possible alternatives to the same structure present in the official listing of the FIPAT (possible terms are in order): Myelencephalon, medulla oblongata and bulb.

In addition, there are other terms being used that are not present on the official list of IAT, like the terms used in eleventh grade. These terms correspond to: Dendrite, myelin sheath, sympathetic and parasympathetic division of the nervous system, among others. In view of this situation, it is suggested to do the appropriated incorporations of this terms in Latin language with their correct translation in the corresponding languages corresponding incorporations are suggested of these terms in Latin with their correct translation in the corresponding languages. Error also found by Park & Park, who observed the presence of unofficial terms besides several eponymous in high school biology textbooks.

These errors were also identified by Kachlik *et al.* (2015), who classify them into seven groups: IAT errors, IAT discrepancies, word multiplication, IAT synonyms, identical terms for different structures, terms too long, and terms missing in the IAT. The latter group includes missing terms in systemic anatomy and clinical anatomy, and a scarcity of terms in variant anatomy, locomotion systems, and topographic anatomy.

In relation to results obtained in the context of teaching and learning environments, recent research shows that student knowledge of anatomy is not obtained for IAT purposes, because there is a wider knowledge of basic anatomical medical concepts using eponyms, a situation caused because the use of IAT is not reinforced during different stages of the student (Parra Gámez *et al.*, 2015) and because teachers use anatomical terms which are inconsistent with FICAT recommendations (Martin *et al.*, 2009). In addition, data demonstrate that clinical anatomists are not consistent in how they use IAT (Martin *et al.*, 2014). This lack of international terminology in teaching is accompanied by curricular proposals (such as the high school curriculum in biology) with errors in the terminology. This is consistent with the fact that there are a large number of published anatomy textbooks which have not been carefully reviewed by experienced anatomists (Manzanares-Céspedes, 2010).

Proposals for improving terminology use in school education processes.

Some authors propose that the improvement in the use of IAT, goes through a series of changes in part by specialists, official list modifications and diffusion of international terminology in morphology (Pawlina & Drake, 2009). Improving accessibility to a complete document including the latest version of terminology is recommended in the different areas of morphology (Martin *et al.*, 2009; Manzanares-Céspedes), as well as creating greater awareness in professionals directly linked to the morphology (Martin *et al.*, 2009; Burdan *et al.*). Along the same lines, there are concrete proposals pointing to more rigorous reviews by journals (Pawlina & Drake), as well as more rigorous writing and/or translation of scientific textbooks because most anatomy teachers, students (university students) and trainees (in the area of morphology) use them (Manzanares-Céspedes). Proposals are pertinent, but in light of research results, they are concentrated on the academy, reducing the impact on the curriculum and teacher and student training in biology and natural sciences.

From the above, we propose 5 focal points which are directly linked to school education and in favor of a correct use of basic international terminology in the area of morphology (Fig. 1). (i) Use of international terminology in school education: Students tend to use the same vocabulary as their teachers (Manzanares-Céspedes), so the correct use of terminology can positively affect students' scientific vocabulary management in morphology. (ii) Professional training of Biology and Natural Sciences teachers under international terminology terms: Implementation of updated terminology requires initial or ongoing training of teachers in which they can incorporate the international terminology guidelines in morphology and other biological sciences disciplines. At present there are almost no initiatives for making changes in educational programs that do not include the training and updating of teachers at a given time, so a strategy for change must necessarily include teacher professional training processes (Vezub, 2007). (iii) Curricular proposals consistent with international terminology use: Educational institutions (MINEDUC, 2018) consider that the use of correct terminology is important (MINEDUC), however it is imperative that curricular proposals incorporate updated terms in their curricular programming. (iv) Supplementary materials using international terminology: It is necessary that guides, tests and textbooks be designed using correct terminology to avoid confusion in students and teachers regarding correct names of structures as well as their correct use. (v) Research focused on the use of international terminology in teaching and learning biology: It is important that new research show how natural science and biology teachers manage basic morphology concepts present in the curriculum. It is also

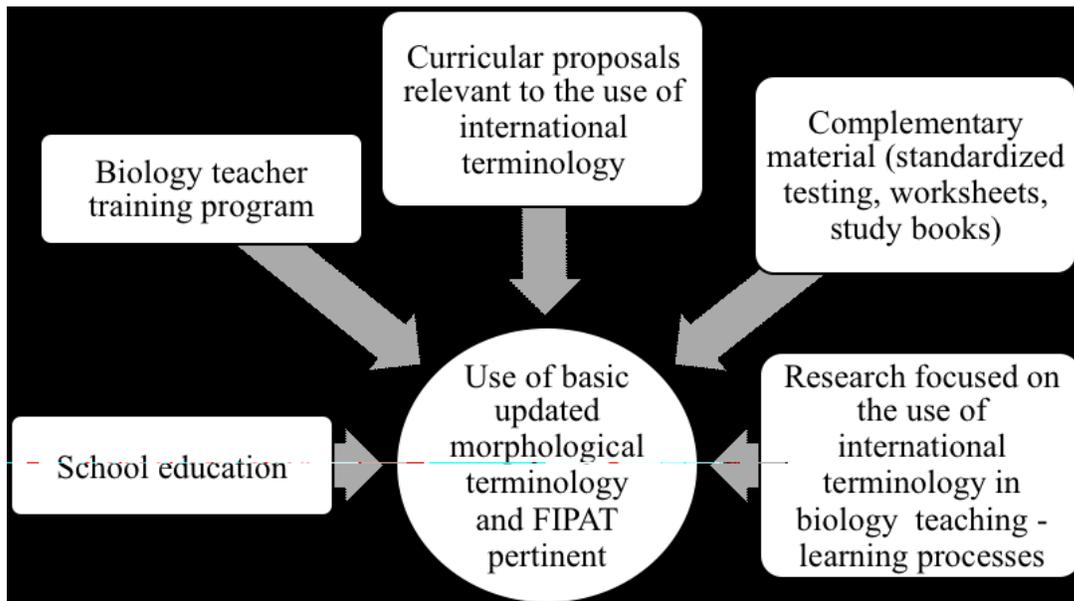


Fig. 1. Curricular proposals to improve the use of terminology in the school education and professional training processes. Five axis are proposed in order to improve the use of basic international terminology on morphological teaching – learning and professional contexts.

important that both, complementary materials and future curricular modifications be studied consistently as to give feedback to corresponding entities about the correct use of international terminology in morphology.

CONCLUSIONS

These results can serve as valuable basic resources for the revision and standardization of terminology used in biomedical fields. Collaboration between anatomists, biologists and high school teachers is a requirement necessary to make changes in the curricula to improve the use of IAT in teacher training and in Biology and Natural sciences classes.

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RESUMEN: En Chile, el currículo nacional de ciencias (biología) es estandarizado y diseñado por el Ministerio de Educación (MINEDUC). Este estudio contribuye a la educación en ciencias analizando el currículo ministerial implementado y su adherencia al Federative International Programme for Anatomical Terminology (FIPAT). El objetivo de este estudio fue evaluar el uso de la Terminología Anatómica Internacional (TAI) en el programa nacional de educación en ciencias, implementado en Chile desde el 2009. Se realizó el análisis de los términos usados en el programa de educación secundaria del MINEDUC (9^{no} a 12^{mo} año). Los términos se identificaron usando el software de análisis de texto Atlas.ti. Luego, se tabularon según: frecuencia, término en latín, traducción al español, uso de términos de acuerdo a FIPAT y tipo de error. Nuestros resultados muestran que el 11,43% de la terminología usada en el currículo de enseñanza de la biología en secundaria no se adhiere a IAT según FIPAT. El 9^{no} grado de educación en biología muestra el mayor grado de uso de terminología FIPAT, no obstante, también muestra la mayor prevalencia de uso incorrecto de términos. Estos resultados sirven como una importante base para la revisión y estandarización de la terminología utilizada en el campo de la enseñanza de las ciencias. La colaboración entre anatomistas, biólogos y profesores es necesaria para ha-

cer cambios en los currículos y mejorar el uso de IAT en la formación docente y en las clases de biología y ciencias naturales.

PALABRAS CLAVE: Terminología anatómica; Educación científica; Estudiantes secundarios; Enseñanza de la biología.

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