International Conference
NEW PERSPECTIVES in SCIENCE EDUCATION
3rd Edition

To Determine and Overcome Biological Misconceptions Held by Students and Educators in the Irish Schooling System

Elaine Galvin, Audrey O' Grady
University of Limerick (Ireland)
Elaine.galvin@ul.ie

Abstract
Misconceptions have become a major concern among researchers in Science Education because they influence how students learn new scientific knowledge, play an essential role in subsequent learning and become a hindrance in acquiring the correct body of knowledge. Senior level Biology is one of the most popular subjects taken by students in Ireland. As this subject relies heavily on rote learning, understanding is rarely tested. This has resulted in a serious level of misconceptions when students enter third level leading to poor grades in introductory Biology modules. Despite the huge number of students taking Biology at senior cycle, there has been no comprehensive study on misconceptions in Biology in Ireland, despite a number of important international studies. It is imperative that the quality of teachers teaching such subjects maintain a high standard to allow their students to excel in the world of Science and the wide range of opportunities it creates. The term misconception can be defined as "any conceptual idea that differs from the commonly accepted scientific consensus". A paper and pencil test was used to assess the students', pre-service teachers' and service teachers' conceptual understanding of fundamental Biology topics. Results from two pilot studies, indicates the presence of high levels of misconceptions amongst upper secondary school students, pre-service teachers and service teachers. A serious concern is the level of misconceptions held by very high achievers. This demonstrates the massive problem of rote learning in Science in Ireland. Students can achieve very high grades and at the same time have little knowledge of the topic or subject. In order to improve the quality of the education system, it is essential that the quality of the teachers is increased. Pre-service teachers should be targeted directly to ensure that they have the capacity to continually question misconceptions they may have and work alongside peers and teacher educators to significantly reduce, if not completely eliminate, these from their pedagogical strategies. Based on the results of the diagnostic test an intervention programme is being developed and integrated on a three tiered level. Tier 1: second level students. Tier 2: pre-service Science teachers. Tier 3: service Science teachers. The effectiveness of these intervention materials will be assessed and analysed both quantitatively and qualitatively. This study raises critical questions about the need for innovative pedagogical approaches to overcome conceptual misunderstandings and has implications for improved dialogical models of teacher continuing education including school-university partnership approaches.

Introduction
The investigation of misconceptions in Biology has been a substantive feature of the work of the Science Education research community for the past 30 years**.** The importance of investigating misconceptions is emphasised by the number of pre-service teachers [1] and service teachers [2] that possess misconceptions and are transferring these misconceptions to the minds of the students they teach [3]. For pre-service teachers in particular, misconceptions are a concern as they may leave their initial teacher education program without having found a way of dealing with this issue. The quality of student achievement is nowadays increasingly understood to depend on the quality of the teachers [4]. Therefore, in order to improve Science Education, it is imperative that teachers find a satisfactory way to identify and amend misconceptions that they may have during their teacher education courses [5].

Formation of Misconceptions
Throughout our lives we are immersed with information. The process of understanding this information can lead to the formation of our misconceptions. Learning Science is a cumulative process and each new piece of information is added to what students already know about the topic at hand. There are a

number of sources that contribute to misconceptions. Misconceptions can result due to the number of contacts students make with the physical and social world around them, they may occur due to something the student experienced in their personal life, from communication with different teachers and friends or through sources of media [6]. Adults play an imperative role in creating misconceptions in students. Studies also highlight that textbooks are another prevalent source that contributes to the formation of misconceptions by students [7].

Amplification of Terminal Examinations

One of the major problems associated with the teaching and learning of Biology in Ireland is the tendency of both curriculum setters and teachers to focus on the excessive use of facts and information. It has been well documented that such an excessive use of facts results in the use of rote learning to gain knowledge in relation to Biological concepts. Rote learning of such concepts results in a poor level of higher cognitive understanding of complex biological concepts. In cases such as this, misconceptions are not challenged or brought to light, allowing learners to hold onto their misconceptions throughout their formal education [8]. The strong tendency to focus on recall and didactic teaching methods within the field of biological education in particular leads to poor depth of knowledge [9].

To overcome and eliminate misconceptions

As teacher educators, service teachers and pre-service teachers have a significant influence on the student's knowledge and understanding, this increases the chances of the misconceptions they hold to be embedded in the students they teach [3]. In order for teachers to implement conceptual change strategies amongst their students, they need to possess a very high standard in their content knowledge and a high degree of awareness of student's misconceptions [10]. It is critical to provide students with opportunities to verbalise their ideas to promote concept building and remediate misconceptions [11]. By simply listening to student's responses and explanations, one can determine if the students' level of understanding is "deep" or "superficial" [12]. Only then will deep–seated misunderstandings be identified, overcome and eliminated [13]. Researchers have found that using good analogies can help students overcome misconceptions as the analogy can assist them in changing the conceptual model they use to think about a scientific phenomenon [14]. Similarly, making students create concept maps in which they are constructing a correct framework for new knowledge has been successful in overcoming misconceptions [15]. Using digital storytelling [16], conceptual change text accompanied by animation [17] and computer games [18] to assist in the classroom to overcome and eliminate students' misconceptions have proven to reduce many misconceptions for students and for some, dismiss them completely [19].

Methodology

A detailed and extensive literature review was carried out to determine misconceptions in Biology that are internationally recognised. A number of misconceptions in many different areas of Biology were identified. Following on from a preliminary study (carried out by the author in 2011/12) a paper and pencil survey was further developed in order to determine the type and level of misconceptions held by second level students and teachers. Forty seven second level schools participated in the research and two teacher training colleges. A total of 991 second level students, 93 pre-service teachers and 34 service teachers completed the survey. After analysis of the literature and the results obtained from the survey it was proposed to develop an intervention programme that would help teachers identify and overcome their misconceptions and their student's misconceptions. The intervention programme consisted of misconceptions incorporated into a third year pedagogy module, implementation and examination of the teaching strategies identified in the literature that bring about conceptual change and a development of a website resource on misconceptions in Biology. The addition of the topic misconceptions to the third year pedagogy module in the University of Limerick was decided as

researchers had stated that teachers are given the role to identify and overcome misconceptions in the classroom without ever being given the advice or resources in their teacher training colleges on how to address them. The identification of misconceptions in Biology is essential for misunderstandings to be addressed and for learning to be developed and advanced [20]. Effective and evidence-informed teaching strategies are clearly needed by the teachers to identify, overcome and eliminate misconceptions in the Biology classroom. These third year pre-service teachers were able to implement these suggested teaching strategies during their fourth year teaching practice. The website resource was developed as a way of getting the information to service teachers. The website includes; literature on Biology misconceptions, Leaving Certificate Biology topics, teaching strategies to identify and overcome misconceptions, example lesson plans, module delivered to pre-service teachers, question forum and an option for teachers to upload their own resources.

Findings

The results of the study suggest that biological misconceptions are widespread among second level students and, although to a lesser extent, are also prevalent among pre-service and service teachers. The overall performance of pre-service teachers indicates that these soon-to-be qualified Biology teachers will possess a variety of misconceptions in fundamental Biology topics which they will bring with them into the classroom. This is a significant problem as the literature states that teachers holding their own scientific misconceptions are unlikely to be able to identify their students' misconceptions or provide educational experiences to overcome pupils' incomplete ideas to overcome misconceptions [5]. Furthermore, they are likely to be unaware that they possess these misconceptions as the education system has failed to make these teachers aware of them. The most prevalent biological misconceptions identified from this study were

- Photosynthesis only takes place in the leaves.
- Interphase is the resting stage and mitosis is the dividing stage of the cell cycle.
- Plants get their food from the soil through their roots.
- Green plants photosynthesise during the day and only respire during the night.
- A food web is a number of discrete food chains represented together in one diagram.

The feedback received from the pre-service teachers that took part in the pedagogy module which incorporated the study of misconceptions was extremely positive. The pre-service teachers' use of conceptual change strategies among students for this study was found to immensely improve students' conceptual understanding of the topic being taught.

Educational Implications

Pre-service teachers are not introduced to literature outlining misconceptions or conceptual change strategies to overcome misconceptions in their initial teacher training programmes. Without educating pre-service teachers to overcome their own misconceptions, as well as identify their pupils' misconceptions we are introducing them into an unremitting cycle where misconceptions remain dominant. University Science Education programs need to interrupt the cycle of misconceptions throughout schooling and help pre-service teachers develop an understanding of ways to identify and overcome misconceptions [21]. To be effective in rectifying teachers' misconceptions and preventing these being propagated to students, teacher education programmes should aim at equipping Biology teachers with the necessary knowledge and skills to use textbooks more critically and selectively, and be alert to the inaccurate information described in textbooks as it is the most significant tool a teacher has while teaching [22]. The widespread presence of misconceptions in second level students further suggests that experienced, practicing Biology teachers are unaware or unconcerned with identifying students' misconceptions and are not using conceptual change strategies. The need for high quality Science graduates in Ireland is highlighted [23]; yet our second level students are evidently achieving high Leaving Certificate grades from rote learning as opposed to true understanding of scientific concepts. This is a problem that needs to be addressed if we are to improve our performance in the

forthcoming Programme for International Student Assessment (PISA) report and establish a superior international reputation.

References

[1] Çalik, M., and Ayas, A. (2005). A comparison of level of understanding of eighth-grade students and science student teachers related to selected chemistry concepts. *Journal of Research in Science Teaching,* 42(6), 638-667.

[2] Kikas, E. (2004). Teachers' conceptions and misconceptions concerning three natural phenomena. *Journal of Research in Science Teaching,* 41(5), 432-448.

[3] Sanders, M. (1993). Erroneous ideas about respiration: The teacher factor. *Journal of Research in Science Teaching,* 30(8), 919–934.

[4] Darling-Hammond, L. (1999). *Teacher quality and student achievement: A review of state policy evidence.* Centre for the Study of Teaching and Policy, University of Washington Seattle, WA.

[5] Burgoon, J. N., Heddle, M. L., and Duran, E. (2010). Re-Examining the Similarities Between Teacher and Student Conceptions About Physical Science. *Journal of Science Teacher Education,* 21(7), 859-872.

[6] Griffiths, A. K., and Preston, K. R. (1992). Grade 12 Students' Misconceptions Relating to Fundamental Characteristics of Atoms and Molecules. *Journal of Research in Science Teaching,* 29(6), 611-628.

[7] Dikmenli, M., and Cardak, O. (2004). A study on misconceptions in the 9th grade high school biology textbooks. *Eurasian Journal of Education Research,* 17, 130-141.

[8] Mintzes, J., Wandersee, J. and Novak, J. (2001). Assessing understanding in biology. *Journal of Biological Education.* 35 (3), 118-124.

[9] Allen, K. and Tanner, K. (2005) 'Approaches to Biology Teaching and Learning: Understanding the Wrong Answers – Teaching towards Conceptual Change', *Life Science Education,* 4(2), 112-117.

[10] Gomez-Zwiep, S. (2008). Elementary Teachers' Understanding of Students' Science Misconceptions: Implications for Practice and Teacher Education. *Journal of Science Teacher Education,* 19(5), 437-454.

[11] Bergquist, W., and Heikkinen, H. (1990). Student ideas regarding chemical equilibrium. *Journal of Chemical Education,* 67, 1000–1003.

[12] Gooding, J., and Metz, B. (2011). From Misconceptions to Conceptual Change. *The Science Teacher,* 78(4), 34-37.

[13] Özmen, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bonding. *Journal of Science Education and Technology,* 13(2), 147-159.

[14] Clement, J., and Brown, D. (2004). Overcoming misconceptions via analogical reasoning: abstract transfer versus explanatory model construction. *Instructional Science,* 18(4), 237-261.

[15] Cullen, J. (1990). Using Concept Maps in Chemistry: An alternative view. *Journal of Research in Science Teaching,* 27(10), 1067-1068.

[16] McLellan, H. (2007). Digital storytelling in higher education. *Journal of Computing in Higher Education,* 19(1), 65-79.

[17] Akamca, G. Ö., Ellez, A. M., and Hamurcu, H. (2009). Effects of computer aided concept cartoons on learning outcomes. *Procedia - Social and Behavioral Sciences,* 1(1), 296-301.

[18] Kara, Y., and Yesilyurt, S. (2008). Comparing the Impacts of Tutorial and Edutainment Software Programs on Students Achievements, Misconceptions, and Attitudes towards Biology. *Journal of Science Education and Technology,* 17(1), 32-41.

[19] Karamustafaog˘lu, S., Sevim, S., Mustafaog˘lu, O., and Cepni, S. (2003). Analysis Turkish high-school chemistry examination questions according to bloom's taxonomy. *Chemical Education Research Practices,* 4(1), 25–30.

[20] Hodgson, C., and Pyle, K. (2010). A Literature review of Assessment for Learning in science. National Foundation for Educational Research.

[21] Asay, L. D., and Orgill, M. K. (2010). Analysis of essential features of inquiry found in articles published in The Science Teacher, 1998–2007. *Journal of Science Teacher Education,* 21(1), 57-79.

[22] Yip, D. (1998). Teachers' misconceptions of the circulatory system. *Journal of Biological Education,* 32(3), 207-215.

[23] Department of Jobs, Enterprise and Innovation (2011) "*Top-class science in Ireland helping to engineer economic rejuvenation" – Sherlock* [press release], 8 September, available: http://www.djei.ie/press/2011/20110908.htm [accessed 17 January 2012].