Lightning – Scientific knowledge versus mythological beliefs

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Abstract. Lightning has more recently wreaked havoc during the rainy season in several parts of South Africa and this prompted the physics community under the auspices of the South African Institute of Physics (SAIP) to devise meaningful strategies for promoting public awareness. In response to this call, first-year Chemical Engineering (National Diploma Programme) students at the University of Johannesburg responded to a carefully designed questionnaire that seeks to probe students' level of understanding of lightning. Analysis of responses reveals lack of scientific understanding of lightning as a natural phenomenon. Amongst others, this can to some degree be attributed to superstitious or cultural beliefs.

Keywords: *alternative conceptions, worldview theory, language barriers, intellectual discourse, multimedia interventions*

1. Background and contextualization

Research on students' alternative conceptions produced a vast array of substantial literature over many decades. It is a known fact to the science education community that students undertake physics studies with their own understandings of the physical world. Students' inadequate understanding of natural phenomena has been widely reported in various settings in an attempt to meaningfully and comprehensively deal with alternative conceptions. These firmly established beliefs have the potential to persist as lingering suspicions in student's mind and can hinder further learning [1].

This research was largely triggered by rather interesting responses obtained from a diagnostic questionnaire administered to a group of first-year Chemical Engineering [National Diploma Programme (NDP)] students at the University of Johannesburg, South Africa. More specifically, the questionnaire administered seeks to probe students' level of understanding of lightning as a natural phenomenon. In a similar vein, researchers employed various multimedia interventions to probe students' understanding of lightning [2] & [3]. In particular, computer-based multimedia learning environments consisting of animated pictures and narrated words were employed for improving students' understanding [2]. Cognitive theory and multimedia design principles were employed to augment findings from computer-based multimedia learning environments [3]. This approach involves the design of multimedia learning environments coupled with reciprocal relation between cognitive theory and educational practice.

2. Theoretical framework

This research is underpinned by the Worldview Theory as the underlying theoretical framework. The Worldview Theory provides a non-rational foundation for thought, emotion, and behaviour and also provides a person with presuppositions [4]. In terms of the Worldview Theory, a person sitting in a science classroom is not just a science student but a thinking human being who sees the world in terms of a variety of other contexts influenced by gender, ethnicity, religion and so forth [5]. The implication of this intellectual discourse is that knowledge is then viewed as depending on a reasonably large number of different concepts, each refined through use, example, and experiences and consequently the intellectual picture of the world inside the student's mind includes prior conceptions or beliefs about the natural

world. The Worldview Theory sees a person as having presuppositions about what the world is really like and what constitutes valid and important knowledge about the world [4]. These presuppositions are regarded as views that a person holds about natural phenomena which include *commonsense*, *alternative frameworks*, *indigenous beliefs*, *misconceptions*, and *valid science* [4]. This in itself provides the justification for using the Worldview Theory as the underlying theoretical framework in this research.

3. Research design

As alluded to earlier, data collection involved the administration of a diagnostic questionnaire to a group of first-year Chemical Engineering (NDP) students (*n = 157*) at the University of Johannesburg, South Africa. The design largely employed quantitative analysis techniques.

4. Focus on the analysis of responses

It is important to point out upfront that students provided varied responses to the diagnostic questionnaire administered as detailed below.

1. *What causes static electricity?*

   A. *Static electricity is caused by stationary charges*
   B. *Static electricity is caused by deficiency of charges*
   C. *Static electricity is a balance between positive and negative charges*

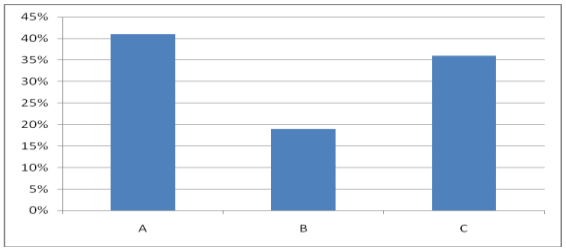

Figure1: Response pattern for item 1.

Item 1 on the diagnostic questionnaire reflects on the cause of static electricity. In terms of the responses, 41% of the students indicated that "s*tatic electricity is caused by stationary charges".* 19% of the students indicated that "s*tatic electricity is caused by deficiency of charges".* While this is not a scientifically correct response, it does seem to highlight some measure of alternative conceptions exhibited by the students. A further 36% of the students indicated that "*static electricity is a balance between positive and negative charges".* This seems to suggest that students cannot differentiate between the terms *"static"* and *"balance"* in relation to the interaction of electrical charges. The interplay between language barriers and scientific understanding appears to be of critical importance in this respect. Both cultural and language concerns should be taken into account in learning situations [6 & 7].

2. *What causes lightning?*

   A. *A massive flow of electric current between the clouds and the ground following separation of charges*
   B. *Witchcraft*
   C. *Thunder*

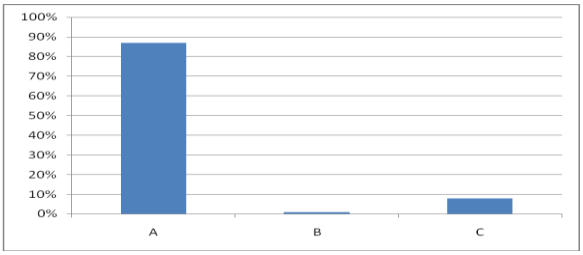

Figure 2: Response pattern for item 2.

Item 2 on the diagnostic questionnaire reflects on the causes of lightning. A vast majority of the students (87%) indicated that lightning is caused by "*a massive flow of electric current between the clouds and the ground following separation of charges".* Additional responses highlighted *"witchcraft"* (1%) and *"thunder"* (8%) as causes of lightning. This seems to suggest students' incoherent understanding of lightning and thunder as natural phenomena.

3. *How is lightning related to static electricity?*

   A. *Lightning is a form of static electricity*
   B. *No relation*
   C. *Both lightning and static electricity happen not because of the attraction between the opposite charges*

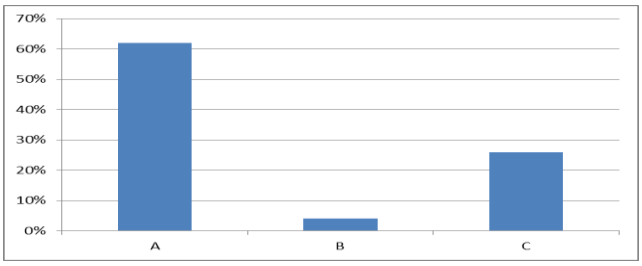

Figure 3: Response pattern for item 3.

Item 3 on the diagnostic questionnaire seeks to establish students' understanding of the relationship between lightning and static electricity. While a substantial number of respondents (62%) indicated that *"lightning is a form of static electricity",* a further 26% indicated that "*both lightning and static electricity happen not because of the attraction between the opposite charges".* These responses paint a somewhat gloomy picture in terms of students' understanding of the relationship between lightning and static electricity.

4. *What causes a spark?*

   A. *Electrons moving across the atmosphere and heating up the air*
   B. *Electrons moving back and forth across the atmosphere*
   C. *Moisture in the atmosphere*

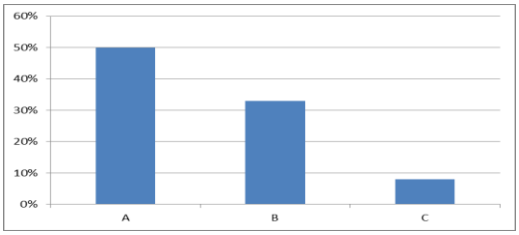

Figure 4: Response pattern for item 4.

Item 4 on the diagnostic questionnaire reflects on the cause of a spark. Some respondents (50%) indicated that a spark is caused by "*electrons moving across the atmosphere and heating up the air".* A further 33% indicated that a spark is caused by "*electrons moving back and forth across the atmosphere"* while 8% indicated that a spark is caused by "*moisture in the atmosphere".* For students to think that a spark is caused by "*electrons moving back and forth across the atmosphere"* and "*moisture in the atmosphere"* seems to suggest a lack of coherent scientific understanding of this natural phenomenon.

5. *How does lightning differ from a spark?*

   A. *Lightning occurs in summer while sparks occur in winter*
   B. *Lightning is a big spark*
   C. *Lightning makes noise but sparks don't*

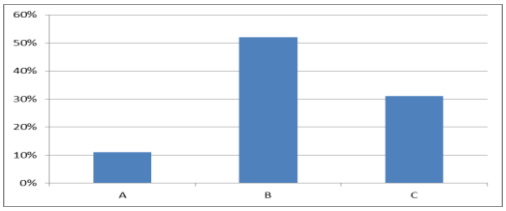

Figure 5: Response pattern for item 5.

Item 5 on the diagnostic questionnaire seeks to establish students' understanding of the difference between lightning and spark. In response to this item, 52% indicated that *"lightning is a big spark".* Other respondents (11%) and (31%) indicated that *"lightning occurs in summer while sparks occur in winter"* and *"lightning makes noise but sparks don't*", respectively. It is interesting to note that some respondents seem to attribute the difference between lightning and spark to seasonal changes which clearly has no scientific basis in relation to the phenomena in question.

6. *What causes electrons to jump across the atmosphere and cause a spark?*

   A. *The force from a large accumulation of positive charge on the other side of the atmosphere*
   B. *Force of gravity*
   C. *Heating up of the atmosphere*

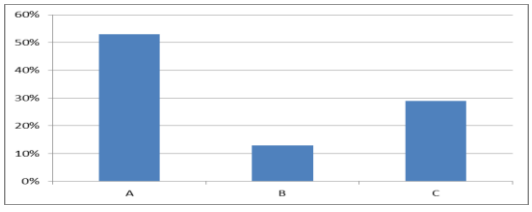

Figure 6: Response pattern for item 6.

Responses to item 6 provided an interesting pattern in the sense that 53% of the respondents expressed the view that "*the force from a large accumulation of positive charge on the other side of the atmosphere"* is what causes electrons to jump across the atmosphere and cause a spark. While 29% of the respondents opted for "*heating up of the atmosphere"* which is scientifically sound, a further 13% opted for *"force of gravity".* The responses in this regard seem to suggest lack of coherent understanding of the nature of electrostatic force and the force of gravity.

7. *What causes thunder?*

    A. *Static electricity popping your eardrums*
    B. *The rapid expansion of air*
    C. *The actions of the rain gods*

The response pattern to this item seems to suggest that the majority of the students (79%) understand that thunder is caused by "*the rapid expansion of air".* However, there are others (17%) and (4%) who hold the view that thunder is caused by *"static electricity popping your eardrums"* and *" the actions of the rain gods*", respectively. This may partly be attributed to religious or mythical beliefs as explained earlier.

8. *How do you minimize the risk of injury from lightning?*

    A. *Going outdoors and standing under trees and near tall buildings*
    B. *Staying indoors*
    C. *Using electrical appliances*

There appeared to be a fair understanding of the minimization of the risk of injury from lightning on the part of the respondents. However, fewer respondents still hold the view that the risk of injury from lightning can be minimized by *"going outdoors and standing under trees and near tall buildings"* and *"using electrical appliances"* which is not in line with precautionary safety measures.

9. *Why should we be away from water when lightning strikes?*

    A. *Lightning conducts through water*
    B. *Lightning does not conduct through water*
    C. *Water attracts lightning?*

While the majority of the respondents (73%) seem to understand that staying away from water when lightning strikes is an important precautionary measure in a scientific sense, there are others (22%) who do not particularly understand the scientific basis for adhering to this safety measure. An understanding of the electrolytic nature of water as a polar compound appears to be inadequate if not lacking.

10. *Is there any connection between lightning and witchcraft?*

    A. *Yes*
    B. *No*

Most respondents (68%) expressed the view that there is "*no connection between lightning and witchcraft".* However, some 27% of the respondents hold the view that there *"is connection between lightning and witchcraft".* This seems to suggest a view or belief deeply rooted in religious or mythical teachings.

5. Recommendations

Myths associated with natural phenomena such as lightning among communities can be addressed through educating the younger generation as it appears to be extremely difficult to eradicate preconceived beliefs among the older generation. The provision of proper education based on established and generally accepted scientific principles to younger generation can produce a chain reaction which might turn out to be beneficial to older generation in the long term. One of the possible ways of achieving the above objective is by broadening the operational agenda and scope of the Physics Education Specialist Group of the South African Institute of Physics (SAIP) for purposes of playing a meaningful and an influential role. It is imperative for funding agencies to make financial resources available for the achievement of this noble goal. Through the provision of these much anticipated financial resources, there could be sessions in future SAIP conferences specifically dedicated to educational seminars and practical demonstrations involving natural phenomena such as lightning, rainbow, eclipse, echoes, typhoons and so forth.

6. Conclusion

Analysis of students' questionnaire responses in this regard suggests incoherence and fragmentation in relation to scientific understanding of lightning as a natural phenomenon. There is an urgent need to embark on an intensive campaign to educate communities about the nature of lightning and related precautionary safety measures possibly with well-informed students from university as educators.

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