Developing a Science Club Programme based on Informal Learning Environments

Matthew Emmanuel Grech Marguerat, Charles Bonello

University of Malta, University of Malta

A great deal of unacknowledged science learning takes place in out-of-school settings like museums, nature centers, and amateur science clubs. Collectively, these settings are referred to as informal learning environments. While there is no single definition of "informal learning", the term generally refers to "science learning that occurs outside the traditional, formal schooling realm . . .".[1] One of the goals of informal science learning environments is to introduce learners to scientific skills and concepts, the culture of science, and the role science plays in everyday life. Informal settings have an advantage in that they can reach people of all ages with varying levels of interest and knowledge. They can also support science learning and provide an insight into how science can be made meaningful to people of all ages, backgrounds, and cultures. Previous studies [2] have investigated the effects of out-of-school Science, Technology, Engineering and Mathematics (STEM) activities aimed at stimulating children's interest in science with positive results. The aim of this study was to design and develop a resource-pack of science activities which would stimulate young students' interest in science in an informal learning environment effectively. Quantitative and qualitative data in the form of an evaluative feedback form and semi-structured interviews were generated from 8 science educators of varying backgrounds and experience. The feedback generated for each activity was utilized for the development of a science club program that could support formal learning.

Keywords: *Informal learning environments, science learning, out-of-school, students' interests.*

1. Introduction

This study investigated the potential of science club activities as an educational tool. Science club activities have long been identified as potentially effective and engaging [1], with research showing that they are capable of empowering students to truly take control over their own learning [2].

2. Literature Review

Science is enhanced when students and teachers have access to the widest number of resources possible. For this reason, educators should consider the role of informal environments in the design of high-quality science learning experiences since such an environment *"complements, supplements, deepens, and enhances classroom science studies"* while increasing *"the amount of time participants can be engaged in a project or topic."* Interaction with said environments beyond the school have also been shown to increase creativity and tap into different learning styles. Indeed, informal learning sites across the globe are moving from the passive "look but don't touch" approach and have developed engaging and interactive exhibitions designed to support inquiry and personal investigation [3].

Science club activities can help students to better understand scientific concepts, processes, and procedure [4]. Such activities enhance student achievement and interest in science and allow students to gain scientific inquiry skills and develop scientific reasoning as well as improve their communication skills [5]. These activities motivate students to work together and share ideas, experience, and knowledge and subsequently, students take ownership of their learning and feel a sense of belonging to a group [5]. Students who view themselves as members of a scientific learning club or community are shown to be more motivated to participate and commit themselves in the activities. When undertaken as out-of-classroom and sometimes after-school programmes, science club activities stimulate students' interests and may positively influence students' academic achievement, as well as build on learners' sense of future career options in STEM fields, with studies indicating that activities set in the real-world and which incorporate students' daily lives also increase their interest in science [6][7]. Therefore, offering a supplementary after-school programme along with regular schoolwork may help students consider a particular science degree at university [8].

3. Methodology

A resource pack was initially prepared for teachers' evaluation. The pack contained 16 activities related to physics, chemistry and biology all aimed at students studying these sciences between the ages of 14-16. Nine science educators were then chosen based on factors such as gender, age, teaching experience, teaching qualification, subject-area, subjects taught, and type of school (i.e., Church, State, or Independent). While all nine educators selected agreed to participate initially, one was ultimately unable to provide her feedback due to time constraints, leaving a sample size of eight participants. A questionnaire related to the resource-pack was then sent as a Google form to the eight participants, three of whom were selected for individual semi-structured interviews, based on the perceived relevance of the feedback they provided in the questionnaire as well as the representativeness of the teachers who were selected.

The questionnaire was divided into three parts:

1. Brief, short, specific questions related to participants' sex, age, teaching experience (referring to both subject taught and duration of teaching career), teaching qualification, subject specialisation, and type of educational institution taught at (i.e., Church, State, and/or independent school).
2. A rating and evaluation of the science club activities, whereby participants were asked to rate each science club activity according to a 5-point Likert scale, and evaluate the different activities according to their respective subject area/s; and
3. Two open-ended exploratory questions on how informal learning activities can be made enjoyable and effective in the context of a science club.

Participants were given 2-3 weeks to evaluate the activities within the programme using the questionnaire. The semi-structured interviews were subsequently conducted via video-call where the participants' views on informal learning environments and, more specifically, on the science club activities that they evaluated were discussed at greater length to obtain a better picture of the perspectives of science educators on this topic.

4. Results and Analysis

4.1: Quantitative Data

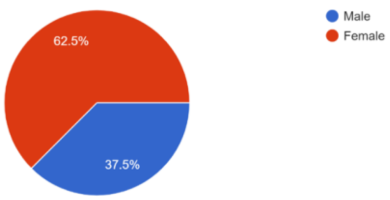

Figure 4.1: Sex

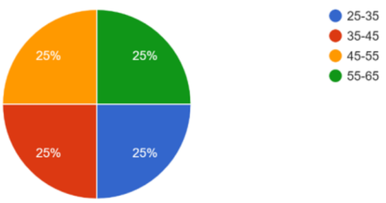

Figure 4.2: Ages

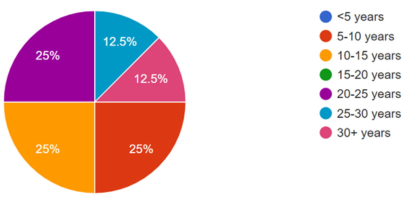

Figure 4.3: Teaching Experience

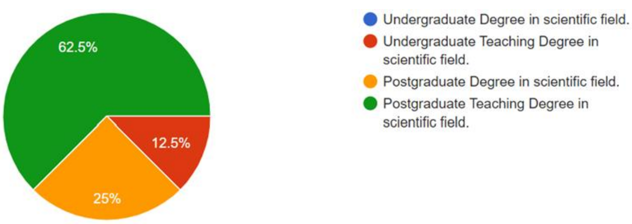

Figure 4.4: Teaching Qualification

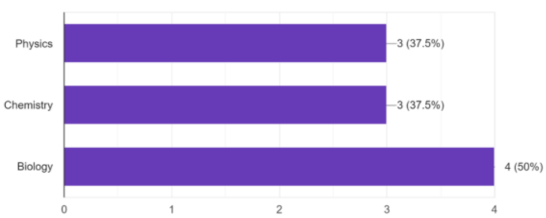

Figure 4.5: Subject Specialisations

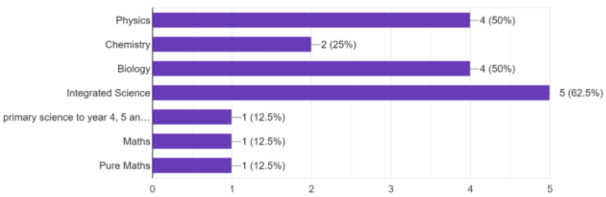

Figure 4.6: Taught Subjects

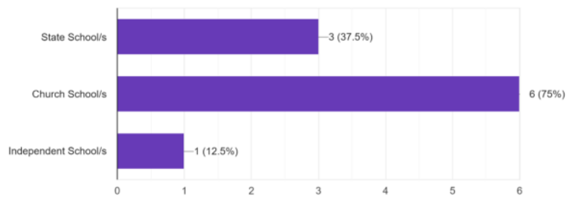

Figure 4.7: Schools Employed

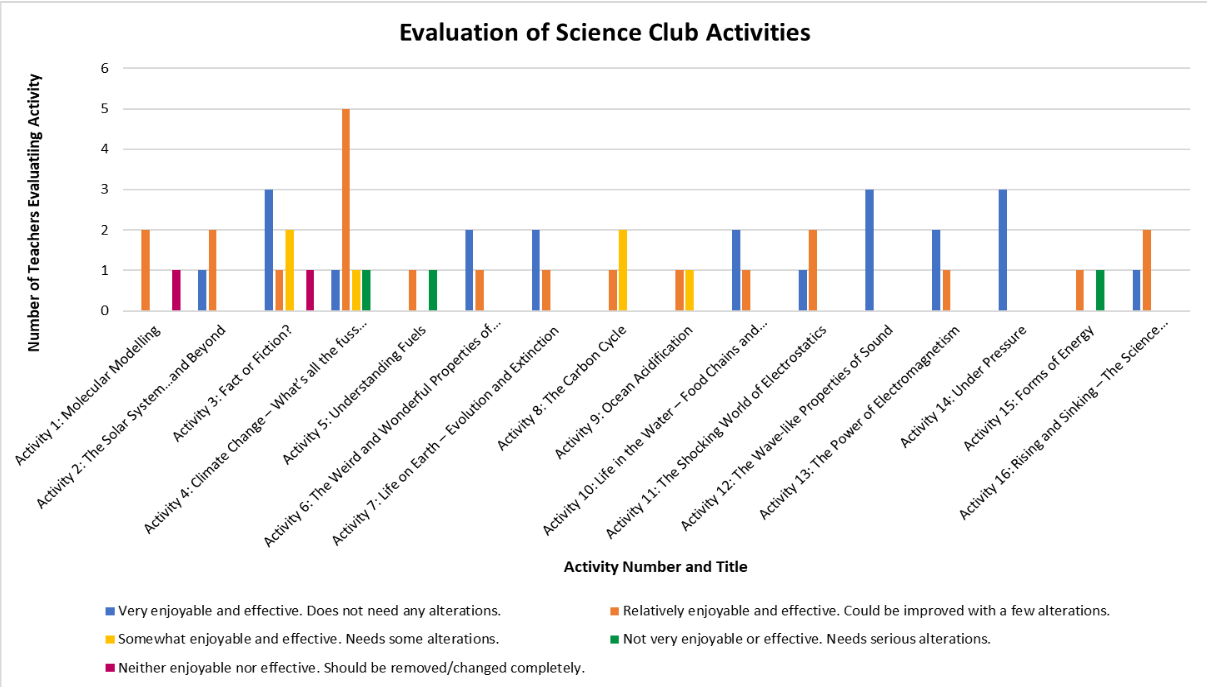

Figure 4.8: Feedback on Activities Prepared

4.2: Qualitative Data

The 'Wow' Factor- "the joy is in the discovery"

Novelty and difference heavily contribute to the curiosity of the student. This was frequently mentioned by teachers, who collectively agreed that no matter how detailed notes and books were, the most effective way for students to recall scientific content was through the creation of experiences which are altogether different from the normal and traditional lesson.

Student-Centred ("Hands-On") Learning – "they choose what they want to do"

Teachers emphasised the need for student-centred activities, with a particular focus on practical, "hands-on" experiences instead of demonstrations. In their view, the most effective educators were those who guided and facilitated rather than dictated and demonstrated. Group-work and student autonomy were frequently mentioned in this regard, as well as collaboration and direct communication with students. Spontaneity and freedom were also mentioned as musts within a science club – to be able to explore, to inquire, to risk, to be different, and – perhaps most importantly, to share. Sharing knowledge acquired through personal experience not only allows students to understand the content more deeply, but each other more deeply, with each student consequently becoming a source of knowledge which the whole class is given access to in a common experience of learning.

Relevance – The Syllabus and Everyday Life

As two teachers stated: *"The aim of our science clubs…is to enhance the learning of our syllabi, so that the students understand more during the lesson…to get students to realise that science is all around them – that it is something which you are interacting with on a day-to-day basis and that helps you understand what you are doing and how things are working"*

Time Constraints and Practical Considerations

In the words of one educator: *"the syllabus is jam-packed! (T)here is not enough time for depth understanding. In the light of all this, it would be fantastic if the students are given this opportunity during the science club activity"*

Critical Thinking – "Skills and Values"

A telling statement by another pair of educators read as follows: *"the main aim should always be to…have…more of a skills-based…and…value-centred approach…it's about values…we give them educational material, but we're not giving them an education…we're not forming them into critical* *thinkers…we are not giving them the tools with which they can use it…it is not…making (them) capable of self-direction in (their) own learning"*

Teacher-Student Relationship – "It's totally different"
The purpose of a science club is not immediately apparent other than a common interest in science by both teacher and student. As one teacher explained, this creates the possibility for a genuine relationship based on mutual trust and collaboration to be formed more easily. This can be contrasted with the reality within a standard lesson, where both teacher and student are forced to be in a classroom for a set amount of time for legal reasons. Such trust leads to an increased spirit of genuineness, which supports the common sense of striving for scientific truth. This kind of interaction is invaluable for the student's education, who during this crucial stage in his/her development benefits hugely from the freedom to confront, debate, and imagine.

Love for the Subject – "I'm here because I want to be here"
One educator reflected how a science club can help to connect a teacher's passion for the subject with the student since its self-directed and voluntary format allows students to feel more at ease and encouraged to learn in an environment where they do not feel compelled to learn.

Differentiation and Competition
While activities in science clubs may not be centred around assessment, some teachers argued that students must learn that, in their education, as in life, one must be in a constant *"competition with (one)self"*, and not simply be defined by someone else. While such an element may not be immediately evident within the context of a science club, there is no reason why such activities could not be designed in such a way as to encourage students to challenge one another for their own self-improvement. In this way, students' learning not only becomes more fun, but more rewarding.

Interdisciplinarity
As one teacher remarked: *"The students don't link subjects together… they see them separately…That thing (that) they don't try to link I see it as…there's a failure in our education system"*

5. Discussion and Conclusions

The nine identified themes were crystallised into three over-arching ones – interest and autonomy, motivation and mastery, and understanding not memorising.

5.1: Interest and Autonomy

Interest as an indicator of academic capability was touched upon by one Biology teacher, when she favoured a consideration of students' personal interests over simply their academic performance. *"students who might be interested in science or…who might be inclined toward the sciences might not necessarily do well academically… high ability might not only refer to students who are obtaining the highest levels of attainment…but who have more of an…interest…to do this in their free time"*
A common theme that emerged from the data was student-centred learning, here linked to 'autonomy'. Autonomy has a powerful effect on individual performance and attitude [9]. Indeed, one of the most revealing feedback items generated through this study was one Physics teacher's explanation of the effect that the voluntary nature of attendance at a science club can have on students: *"I'm not here because…I have to be here… [but] I want to be there! This…gives a new dimension…to the activity. I'm here because I want to work and have…it's not someone told me to be here… I want to be here. That helps a lot!"*

5.2: Motivation and Mastery

Humans are naturally motivated to develop competence and to solve problems. Motivation affects the amount of time people are willing to devote to learning, with studies showing how earners of all ages are most motivated when they when they are passionate about what they are learning (i.e., they can see the usefulness of what they are learning and use that information to do something that is impactful for them) [10]. As one teacher illustrated: *"the information… is passed on to make an impact on the student's life, not just on the students' categorisation of science as a subject…you will hear about students going home and speaking to their parents about what they learnt or their change in attitude towards something…"* In this way, students can see the intrinsic value of what they are learning, and how what they are learning can span multiple domains of knowledge.

5.3: Understanding, not Memorising

Learning with understanding is more difficult than memorising and more time-consuming. Many curricula fail to support learning with understanding because they present too many disconnected facts in too short a space of time. This issue was raised by a Physics teacher, who voiced her concerns at the lack of opportunity, time, and focus on and for the deepening of knowledge as opposed to its mere acquisition – *"there is not enough time for depth understanding".* The key to expertise is the time for the mastery of concepts that allow for deep understanding of that information, thus transforming it from a set of facts into usable knowledge and larger overarching ideas. Such a conceptual framework allows learners to organise information into meaningful patterns and store it hierarchically in memory to facilitate retrieval for problem-solving [11].

5.4: Limitations

A larger sample size of science teachers would have been more representative of their perspectives and experiences of informal learning activities. While a larger population would have needed more time to prepare in terms of its selection and data generation, it would certainly have provided a richer view of teachers' opinions and experiences. Another limitation was the lack of teachers coming from a background of work within independent schools in Malta.

5.5: Recommendations

Concrete action inspired by the emergent research on recent improvements to learning must occur. Specifically, the issues of time and the syllabus must be addressed, with a view to allowing greater freedom for teachers to go in-depth on certain topics of increased relevance. Allowing both teachers and students the possibility to explore these interesting and meaningful subjects will naturally enhance the learning experience for all concerned due to the shared meaning and value which can be found within them. In this light, changes to the syllabus to a more stream-lined iteration focusing more on topics of relevance and consequence should be enacted, while teachers from different subject areas should be encouraged to collaborate with one another and organise more school projects, site-visits, and lessons that adopt a transdisciplinary approach to knowledge to consider increasingly complex present-day issues. Research can also be initiated in this area to study the results of such interdisciplinary undertakings, with a view to improving them.

6. References

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