Part 12 / Strand 12

Cultural, Social and Gender Issues in Science and Technology Education

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Part 12. Cultural, Social and Gender Issues in Science and Technology Education

Equity and diversity issues: Sociocultural, multicultural, bilingual, racial/ethnic, gender equity studies and science education for the special needs.

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EPISTEMIC REFLECTION AS AN EMERGING TEACHING PRACTICE IN CULTURALLY DIVERSE CLASSROOMS

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Nowadays, classrooms are culturally and epistemologically diverse. When teachers confront this diversity, they might enact an exclusionary or inclusive relationship between such epistemologies. This research aims to identify emerging practices when science teachers use the Epistemological Bridge (EB) approach between the epistemology of science and traditional epistemologies. The EB is a didactic process during which teachers engage students in producing learning outputs by establishing an inclusive relationship between the epistemology of science and traditional epistemologies. Three teachers participated in a qualitative study on their practices guided by the EB. Teachers conducted students in explaining phenomena from chemistry and indigenous epistemologies. As a result, the three teachers enacted an 'epistemic reflection' because they addressed with students the nature, structure, and use of each epistemology's ideas, practices, and explanations. This emerging practice is framed into the Nature of Science (NOS) approach. When teachers teach the NOS, they can guide students in deconstructing science and understanding its domain compared to other epistemologies. Additionally, this emerging practice has support in empirical evidence from other studies. For example, some researchers sustain the positive effect of the teaching practice of 'making the rationale of scientific explanations explicit' on the student's explanations.

Keywords: Cultural Diversity, Epistemology, Teaching Practice

INTRODUCTION

Epistemological reflection emerges as a teaching practice by enacting an inclusive relationship between epistemologies from different cultures in the science classroom. Nowadays, classrooms are culturally diverse because of the plural population composition and or the immigration processes. This cultural diversity means that the epistemology of the subject matters and the epistemologies of the students'- teachers' cultures coexist in the classroom. When teachers experience this diversity, they might enact an exclusionary or inclusive relationship between such epistemologies. This research aims to identify emerging practices when science teachers use the Epistemological Bridge approach between the epistemology of science and traditional epistemologies.

To study the interactions between epistemologies in the science classroom is an issue related to social justice. Collste (2019) argues that some cultures consider others as inferior in culturally diverse societies. In this scenario of injustice, the majority dominates the epistemologies of the minorities. For the author, overcoming the epistemic injustice is reciprocal recognition and respect. To this perspective, Walsh (2009) adds that it is also necessary to recognise the unequal power relationships between cultures for social justice. In this way, teaching practices contribute to social justice when, in addition to science, they consider other epistemologies as valid curricular content (Rodríguez & Morrison, 2019).

Relationships between epistemologies (cultures) in the science classroom

Different theories or approaches describe the relationships between epistemologies in the science classroom. For example, in Brazil, Ludwig and El-Hani (2020) describe two central relationships between school science and local knowledge systems. One relationship is marginalisation, and the other is recognition. Thus, teachers can marginalise local knowledge systems by ignoring them or using them overlapped with science. Meanwhile, teachers recognise local knowledge when using it as content in the curriculum. In Canada, Aikenhead (1996) describes the possible bridge between epistemologies belonging to different cultures. Therefore, teachers might guide indigenous students to cross their cultural borders and enter the school science culture.

Likewise, in Colombia, Molina and Mojica (2013) identify two essential science education foci. The assimilationist approach happens when teachers solely take into account school science. Inclusive teaching occurs when teachers consider school science and Traditional Environmental Knowledge. This open view establishes different bridges between cultures in different levels (a) moral and human, (b) ontological and epistemological, and (c) social and contextual. Additionally, in South Africa, Mpofu, Otulaja and Mushayikwa (2014) describe possible integrations between epistemologies in a science classroom (a) substitutive, (b) divergent, (c) parallel, and (d) convergent. Teachers enact a convergent integration when they establish dialogues between epistemologies.

The epistemological bridge (EB) to design epistemologically inclusive practices

The Epistemological Bridge (EB) is a didactic process (planning, teaching, learning and assessment) during which teachers engage students in an inclusive relationship between the epistemology of science and traditional epistemologies (Tovar-Gálvez, 2021 a). The traditional epistemologies might encompass the thought systems from indigenous, afrodescendants, farmers, immigrants and other communities (different to the modern Western culture). Communities achieve the inclusive relationship when they reciprocally recognise the existence of diverse epistemologies, validate their contribution to understanding or intervene in reality, and participate in them (Tovar-Gálvez & Acher, 2019). The students' learning outputs mediated by the EB could be –explanations, models, problem-solving, and projects. The bridge is a common way-connection between different endpoints-epistemologies.

When teachers guide their practice (planning, teaching and assessment) from the EB, they recognise that there are other epistemologies in addition to the epistemologies of science. Likewise, teachers validate the contribution of the diverse epistemologies to the school curriculum. Additionally, teachers use such epistemologies as content for the students' learning output. When students use the EB, they participate in every endpoint-epistemology, and for this, they use common elements between epistemologies (walkway) to transit among them.

To support teachers in using the EB for planning and enacting epistemologically inclusive practices, Tovar-Gálvez (2021 a) proposed two practical principles. Those principles describe practices' characteristics from the EB:

A) Epistemological Independence: the epistemologies have their own domain (ideas, practices, instruments, aims, norms and values). Using this principle, teachers identify the domain of every epistemology as content to teach. Those domains are the endpoints of the bridge. There are as many endpoints as recognised cultures in the classroom.

B) Epistemological Similarity: the epistemologies have elements in common that allow communities to establish epistemological interaction. Using this principle, teachers identify elements from each epistemology that resemble each other. The walkway to transit between one epistemology and others are those commonalities. Communities might transit in any direction and moment. The common elements could be values, ideas, practices, procedures, aims, norms, artefacts, and others.

METHOD

Three chemistry teachers from secondary schools in Colombia participated in this study. The researcher supported teachers in planning and enacting the Epistemological Bridge to conduct students to propose explanations on a situation (Tovar-Gálvez & Acher, 2021). Such a situation should be an unknown phenomenon for students but daily. Students should explain this situation by using chemistry and traditional epistemologies. Teachers 1 and 2 chose chemistry and the epistemology of the Muisca indigenous community. While teacher 3 selected chemistry and the epistemology of the farmers and the Wayú indigenous community. Finally, students should produce two explanations on the same situation, one from the scientific referent and another from the traditional referent.

Teachers provided the researcher with the lessons' planning, recordings (audio or video), field notes, pictures of the blackboard, and reflections.

The analysis used as sources all the information transcribed (descriptions in the case of pictures). The analysis consisted of grouping data by content until saturation (Páramo, 2015). Thus, epistemic reflection is an emerging category.

RESULTS

The three teachers enacted an "epistemic reflection" because they addressed with students the nature, structure, and use of the ideas, practices, and explanations of each epistemology in terms of their independence (to a large extent) and their similarity (to a lesser extent).

Teacher case 1

Example of when teacher 1 enacted epistemological reflection with the students:

> But on both sides, are we going to have the same liquid? [In this case] what happens is that I am analysing it from different ways of thinking, which is also the reality in knowledge. For example, Juan, two people can be analysing him. [In the] example, he [a third student] is a sociologist, and I am a scientist. The sociologist may be studying his behaviour, and I will be analysing his structure. These are ways of interpreting an object or a phenomenon. In this case, we are interpreting a single entity. […]. So, are both forms of interpretation valid? They demonstrated it because each of them has a way of interpreting the phenomenon […]. Ancestral thought does not lose its validity because it does not have numbers, nor does scientific thought lose its validity because it does not have a dialogue. [Both] are ways of seeing the world [...].

In the context of the extract, the teacher communicates to the students the work that they will develop the next few days. He highlighted that they would characterize a drink from two thought systems, the scientific and the indigenous. During this planning with the students, the teacher describes the dynamic of explaining the same element or entity from different viewpoints. He underlines the difference between the explanations and the validity of their domains. The teacher is enacting epistemological independence when he delimits the use of every epistemology and respects their domains. Likewise, he enacts epistemological similarity when he points to similar values: both viewpoints provide explanations, and both are valid.

Teacher case 2

Example of when teacher 2 enacted epistemological reflection with the students:

> Each of these two types of knowledge [from farmers and science] has or manages its own language. When we consulted or watched the video "Puros Criollos", how did they talk about the preparation of Chicha [corn drink]? What words were used? [Student says: we must let it "enjuertar"]. Perfect "su persona". They [the farmers] used everyday language. We watched that video produced in Boyacá. In what place was it recorded? Do you remember the man who was drinking the Chicha? In what place [were they]? [Student says: where the land is farmed]. They were in a Tejo court, playing Tejo and drinking Chicha. On the part of scientific knowledge, we consult some concepts related to fermented beverages. Then I explain: we will produce two types of knowledge: scientific knowledge and cultural knowledge.

In the transcription, the teacher evokes a video that she and the students watched the days before. The video is a chronicle regarding the Chicha production. Chicha is a corn-based fermented drink, sacred-healing for indigenous and traditional for farmers. In this case, the teacher addresses the difference between farmers' everyday language and scientific language. In general, she encourages students in using the language according to the cultural context. The teacher enacts epistemological independence when delimits the languages to the corresponding epistemological domains. In addition, she enacts epistemological similarity when making evidence that both epistemologies have languages as a common but different element between them.

Teacher case 3

Example of when teacher 3 enacted epistemological reflection with the students:

I want to remember our question, "Why can sea salt be good for cicatrizing?" And I want to know if you have identified a mistake. For the scientific production practice, what materials did we use? [Pointing to the board, the picture where the scientific and the traditional schemes are] [Students: materials of the scientists] True and did you remember that we said we should not mix them? And we also use the lab coat. Now, let's say what we used during the traditional practice. [Students: the meat, the Petri dish or box, the lab coat] Well, the meat, the lab coat, you said: "that box". That is not a box but a Petri dish, right?. Now, what is the mistake here? I will repeat. [Student: Petri dish] [Another student: [the mistake] is that we put the meat in this box]. And why putting it in this "box" is a mistake? [Students: because that is scientific and not traditional, it must have been on a platter]. Yes, because that is not traditional (element), and we had to put it on a platter or a table for salting. During the traditional practice, the farmers, natives and grandparents, did they use lab coats? What did they use? [Student: nothing]. They use nothing or an apron. So, do you realize that we mixed things up? And we made a mistake there. What have we to take into account? We mixed the elements of the traditional (domain) with the scientific (domain).

In the previous example, the students had finished the scientific production practice. After the chemistry lab, they kept the materials and immediately developed the traditional production practice. However, the students forgot to take off their lab coats during traditional practice. In the next session, the teacher motivated the students to deliberately reflect on the nature of production practices and on a lack of the principle of epistemological independence. The teacher takes up in the class the events of the production practices carried out last week and not only limited to the contents. She also worries about doing epistemological surveillance and identifying that the mixed elements correspond to epistemologies of different nature. Thereby, the epistemology becomes explicit and is part of the content to teach.

DISCUSSION

The epistemological reflection that teachers involved students with might be part of the Nature of Science (NOS) frame. Studies such as those of Schwartz and Lederman (2002) and Akerson and Hanuscin (2007) demonstrate the positive effect of NOS on the teachers' and students' science learning. Teachers have included NOS explicitly in the science curricula in two ways (Khishfe & Lederman, 2006): integrated (in a context) and non-integrated (analysing science structure), with positive results on students' learning in both cases. In the case of Meyer and Crawford (2011), they use the NOS as a way in which teachers involve students from diverse cultures in deconstructing science. The effects that the authors argue for students are (a) they can distinguish science from other epistemologies, (b) this is an opportunity to transit between cultures, and (c) they will understand science as a way of knowing.

In the three cases, the teachers explicitly address with students the nature, structure and dynamics of science and indigenous-farmer thought systems. This explicit NOS goes beyond the research field limits because this is a comparison-based epistemological reflection. Moreover, this epistemological reflection is on epistemologies with different natures and cultural backgrounds. Thus, this NOS is in the context of the epistemological bridge through the epistemological independence and epistemological similarity principles. Therefore, the epistemological reflection probably contributes to students learning from a culturally inclusive point of view.

Likewise, the reflection made by the three teachers regarding the nature and structure of the explanations is consistent with the studies of McNeill, Lizotte and Krajcik (2005) and McNeill and Krajack (2008). The authors studied the effect of instructional practices on the students' explanations. They provided evidence on the positive effect of the practice of "making the rationale of scientific explanations explicit" on the student's product. The same studies support the researcher's recommendation to teachers 2 and 3 regarding using the examples of explanations provided as part of the planning and enactment (Tovar-Gálvez, 2021 b). The expected effect was that they reflected explicitly with the students on the explanations' structure within the EB framework and worked on models of explanations. The evidence provided by McNeill et al. (2005) and McNeill and Krajack (2008) demonstrated a positive effect of the practice of "modelling scientific explanations" on the students' product.

REFERENCES

Aikenhead, G. (1996). Science education: border crossing into the subculture of science. *Studies in Science Education*, 27, 1-52. https://www.tandfonline.com/doi/abs/10.1080/03057269608560077

Akerson, V. & Hanuscin, D. (2007). Teaching nature of science through inquiry: results of a 3-year professional development program. *Journal of research in science teaching, 44*(5), 653–680. https://doi.org/10.1002/tea.20159

Collste, G. (2019). Cultural pluralism and epistemic injustice. *Journal of Nationalism, Memory & Language Politics, 13*(2), 1–12. https://doi.org/10.2478/jnmlp-2019-0008

Khishfe, R. & Lederman, N. (2006). Teaching nature of science within a controversial topic: integrated versus nonintegrated. *Journal of research in science teaching, 43*(4), 395–418. https://doi.org/10.1002/tea.20137

Ludwig, D. & El-Hani, Ch. (2020). Philosophy of ethnobiology: understanding knowledge integration and its limitations. *Journal of Ethnobiology 40*(1), 3-20. https://doi.org/10.2993/0278-0771-40.1.3

McNeill, K. L. Lizotte, D.J., & Krajcik, J. (2005). Identifying teacher practices that support students' explanation in science. *Annual meeting of the American Educational Research Association*. Montreal: AERA. http://www.project2061.org/research/ccms/site.archive/documents/Idendifying_Teacher_Practices.pdf

McNeill, K. L. & Krajcik, J. (2008). Scientific explanations: Characterizing and evaluating the effects of teachers' instructional practices on student learning. *Journal of Research in Science Teaching, 45*(1), 53-78. https://doi.org/10.1002/tea.20201

Meyer, X. & Crawford, B.A. (2011). Teaching science as a cultural way of knowing: merging authentic inquiry, nature of science, and multicultural strategies. *Cultural Studies of Science Education, 6*(3), 525–547. https://doi.org/10.1007/s11422-011-9318-6

Molina, A. & Mojica, L. (2013). Teaching as a bridge between scientific knowledge at school and traditional ecological knowledge. *Magis, Revista Internacional de Investigación en Educación, 6*(12), 37-5. https://doi.org/10.11144/Javeriana.m6-12.ecpe

Mpofu, V., Otulaja, F., Mushayikwa, E. (2014). Towards culturally relevant classroom science: a theoretical framework focusing on traditional plant healing. *Cultural studies of science education*, 9, 221–242. https://doi.org/10.1007/s11422-013-9508-5

Páramo, D. (2015). La teoría fundamentada (Grounded Theory), metodología cualitativa de investigación científica. *Pensamiento & gestión, 39*, 119-146. http://www.scielo.org.co/pdf/pege/n39/n39a01.pdf

Rodriguez, A. J., & Morrison, D. (2019). Expanding and enacting transformative meanings of equity, diversity and social justice in science education. *Cultural Studies in Science Education, 14*(2), 265–281. https://doi.org/10.1007/s11422-019-09938-7

Schwartz, R & Lederman, N. (2002). It's the nature of the beast: The influence of knowledge and intentions on learning and teaching nature of science. *Journal of research in science teaching, 39*(3), 205-236. https://doi.org/10.1002/tea.10021

Tovar-Gálvez, J. C. (2021 a). The epistemological bridge as a framework to guide teachers to design culturally inclusive practices. *International Journal of Science Education, 43*(5), 760-776. https://doi.org/10.1080/09500693.2021.1883203

Tovar-Gálvez, J. C. (2021 b). Explicaciones como producto del puente epistemológico entre culturas. *XI Congreso Internacional sobre Investigación en la Didáctica de las Ciencias, (1697-1700)*. Lisboa: Enseñanza de las Ciencias. https://bit.ly/3jJzGu5

Tovar-Gálvez, J. C. & Acher, A. (2019). Relaciones entre la epistemología de las ciencias y las epistemologías tradicionales: contribuciones a la práctica didáctica. *CIMIE19*, 1-7. Lleida: AMIE. https://amieedu.org/actascimie19/wp-content/uploads/2020/05/Ponencia-en-PlantillaCIMIE2019.pdf

Tovar-Gálvez, J. C. & Acher, A. (2021). Design of Intercultural Teaching Practices for Science Education based on evidence. *Enseñanza de las Ciencias, 39*(1), 99-115. https://doi.org/10.5565/rev/ensciencias.2891

Walsh, C. (2009) Interculturalidad, estado, sociedad luchas (de)coloniales de nuestra época. Quito: Universidad Andina Simón Bolívar.

CONDITIONS OF INCLUSION IN THE CONTEXT OF VOCATIONAL EDUCATION

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Vocational schools in Germany play a major role in preparing young people for the labor market since they offer a large variety of courses, which are mostly job-related but also lead to general educational qualifications. In view of demographic change and the lack of skilled workers in many professions, it is even more important to make the education system and thus the labor market more accessible (Heinrichs & Reinke, 2019). However, a large variety of courses results in a significant diversity among students, necessitating the implementation of inclusive teaching (Euler & Severing, 2014). Inclusive teaching for heterogeneous students, asks for improved institutional framework conditions and especially a sufficient knowledge and an open mind-set of teachers (e.g., Amrhein, 2011). Studies show that attitudes, self-efficacy and willingness are relevant variables when analyzing teachers' decisions and actions in the classroom concerning inclusion (e.g., Lambe & Bones, 2006; Schlüter, 2018). In this project, the perspectives of various actors in the vocational school context are examined to uncover inclusion-related needs at vocational schools as well as analyzing and comparing pre-service teachers' planning and conducting competences for inclusive lessons.

Keywords: Inclusion – Vocational Education – Universal Design for Learning

THEORETICAL BACKGROUND

Perspectives on Inclusion

"[T]he concept of inclusion […] emphasiz[es] the need to reach all learners, on the assumption that every learner matters equally and has the right to receive relevant, quality, equitable and effective educational opportunities." (UNESCO, 2020: 5)

This definition of inclusion put forward by the UNESCO, represents the wide understanding of inclusion adopted in this study, whereby neither gender, social or economic prerequisites nor special educational needs hinder a person to reach his or her potential. Following this ideology, diversity is seen as a chance rather than a challenge that needs to be overcome (Reich, 2018; UNESCO, 2020). Another pillar for inclusive education in Europe is the Sustainable Development Goal 4 within the 2030 Agenda for Sustainable Development which aims to "[e]nsure inclusive and equitable quality education and promote lifelong learning opportunities for all" (UNESCO, 2020:2). The agenda was adopted by 184 member states in 2015 and sets goals to fight poverty on a global scale. These UNESCO goals go a step further than the UN Convention on the Rights of People with Disabilities (UN-CRPD) and do not only include people with disabilities and handicaps but all people with their differing abilities and socio-economic background. In Germany, efforts to implement inclusion in education and at the workplace have been especially strong since signing the UN-CRPD in 2009.

Universal Design for Learning (UDL)

The framework Universal Design for Learning puts forward a possibility to minimize barriers in educational contexts to facilitate learning for all. It is a general pedagogical approach structured through guidelines and checkpoints, which can be adapted and applied for any discipline and subject, enabling students to "access and participate in meaningful, challenging learning opportunities" (CAST, 2018) in the areas of representation, expression and engagement (Spooner et al., 2007; Meyer, Rose & Gordon, 2014; CAST, 2018). UDL takes the needs of all learners into account and aims to provide the most accessible approach to educational content for all students. The checkpoints to each guideline offer concrete advice and examples on how to cater for diverse students and guide teachers through planning and delivering a lesson with "maximum accessibility" (Wember & Melle, 2018). Meyer et al. (2014) base their research on neuroscientific evidence whereby the areas of representation, expression and engagement can be allocated to three networks of the brain (Fig. 1).

The "What" of Learning Recognition Networks 	The "How" of Learning Strategic Networks 	The "Why" of Learning Affective Networks 
Provide Multiple Means of Representation.	Provide Multiple Means of Action and Expression	Provide Multiple Means of Engagement.

Figure 1. The three Networks of Learning and the Basic UDL-Principles (cf. CAST, 2018).

The framework is divided into the three networks and principles with three guidelines and three to five checkpoints each. In Figure 2, a part of the framework's structure is shown considering the Affective Networks and one of their principles.

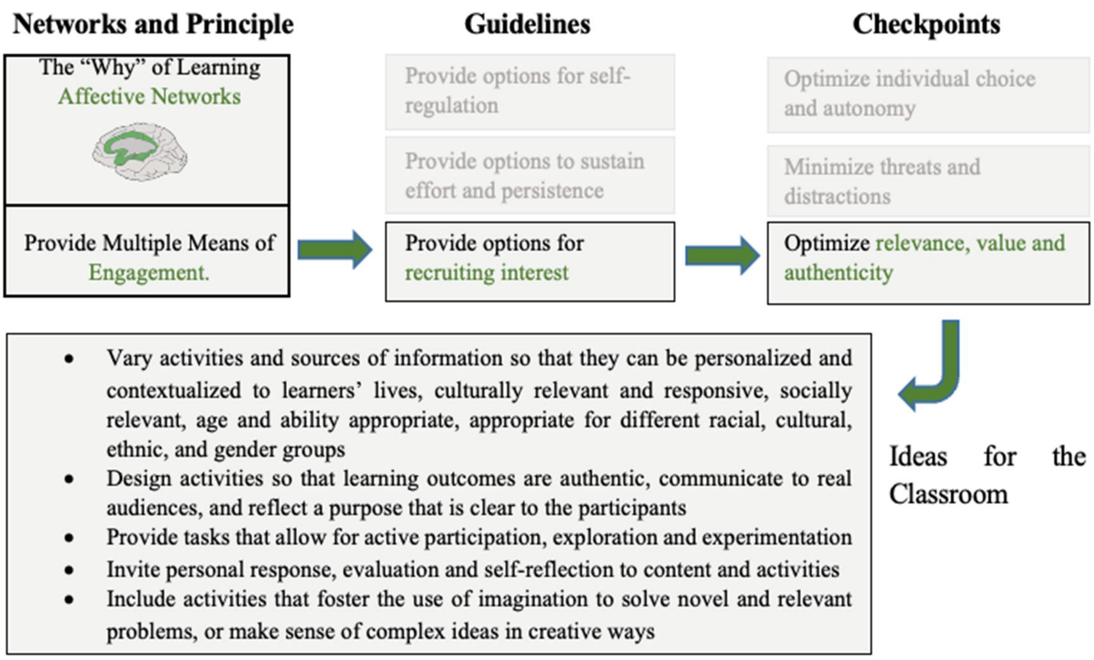

Figure 2. Example of a UDL-principle, guideline, checkpoint and ideas for the classroom (cf. CAST, 2018).

The effectiveness of UDL on the learning process of all learners has been proved by several studies and especially in the USA it is a teaching methodology applied from elementary to tertiary education (Al-Azawei, Serenelli, & Lundqvist, 2016; Capp, 2017). Additionally, UDL is especially effective when focusing on the social and emotional well-being of students and teachers leading to a more productive classroom environment and improving student's instructional engagement as well as their academic achievement. For teachers, planning and conducting their lessons according to the UDL-principles reduces stress, increases job satisfaction, and improves teachers' self-efficacy related to inclusion (Hymel & Katz, 2019).

Vocational Education and Training (VET) in Germany

In Germany, VET plays a major role in preparing the future workforce for a wide variety of jobs. The main goal of VET is the provision of comprehensive vocational, social and personal competences and the preparation for lifelong learning, enabling graduates to participate and actively shape increasingly international developments in society and business (APO-BK, 2019). Internationally, Germany is known for its dual system, which combines theoretical learning at vocational schools and practical learning at the workplace. However, vocational schools also offer certificates for single and double qualification courses and general education qualifications. Thus, vocational schools are an important part in the education system, giving people with low initial qualifications the opportunity to receive vocational and general education with the possibility to attend university. A large variety of courses makes for a diverse group of students, even within a single class. Therefore, heterogeneity is an everyday reality for teachers at these schools. In the effort for inclusion across all educational institutions, vocational schools have rather been underrepresented in research and politics (e.g. Smith & Bell, 2015). Nevertheless, the parties involved agree that modern vocational education and training needs to cater for all needs and that young people should be offered opportunities in the regular system of VET wherever possible, instead of setting up special paths (i.e. SEN schools) and measures that do not lead to the initial training market and finally the labor market. The focus should be on the resources and talents of all young people, especially in light of the current debate about skilled workers and demographic change (Gillen & Wende, 2017).

Research Question

The identified research needs in the context of VET and inclusive teaching put the focus of this study on the evaluation of conditions of inclusion at vocational schools from multiple perspectives, aspiring to create a detailed insight into the current situation. In this paper, the emphasis lies on the following research question: What difficulties do masters' students and pre-service teachers face when planning and implementing inclusive lessons at vocational schools?

METHOD AND INSTRUMENTS

For this study, pre-service teachers' written lesson plans (N=30) were examined with a focus on the consideration of heterogeneity among students. The UDL framework functioned as a guideline for the deductive development of a coding manual, which was adapted for the vocational school context. Two raters conducted the rating of the written lesson plans. From this sample of 30 individual lesson plans, a sub-sample of n=8 was further analyzed. The analysis includes a paper-pencil questionnaire for participants, which surveys attitudes, self-efficacy and willingness with regard to inclusive teaching using Likert-scale and open question formats (cf. Schlüter, 2018). Additionally, a non-participatory, structured and overt observation of the lesson corresponding with the written lesson plan using a slightly altered coding manual is carried out. Whenever the Covid-regulations allowed, this observation was done with two raters. At the end of the lesson, a paper-pencil questionnaire was distributed to students of the documented lesson regarding the perceived adaptivity of the lesson and their personal attitude towards the conducted lesson. The in-service teachers' point of view was evaluated through a short interview directly after the lesson. To conclude the study, a structured interview with participants was scheduled to reflect on the lesson. The sample consists of masters' students of the biotechnology teacher training program at university and of pre-service teachers with the study courses biotechnology, biology and chemistry. Data collections was finalized at the end of 2021. For this paper, some assorted findings on prospective teachers' competences in planning and conducting a lesson are presented.

ANALYSIS AND FINDINGS

To take a closer look at the planning competences of participants, an analysis of 30 lesson plans was carried out by two raters resulting in an intercoder reliability between .73 and .96 (Kappa). Six lesson plans were by university students in their practical semester at a vocational school; the other 24 lesson plans were provided by pre-service teachers currently in the last stage of training at a vocational school. Overall, 655 codes were distributed, ten being the lowest and 39 being the highest number of codes in one lesson plan. Figure 3 visualizes the distribution of codes on the UDL principles and guidelines.

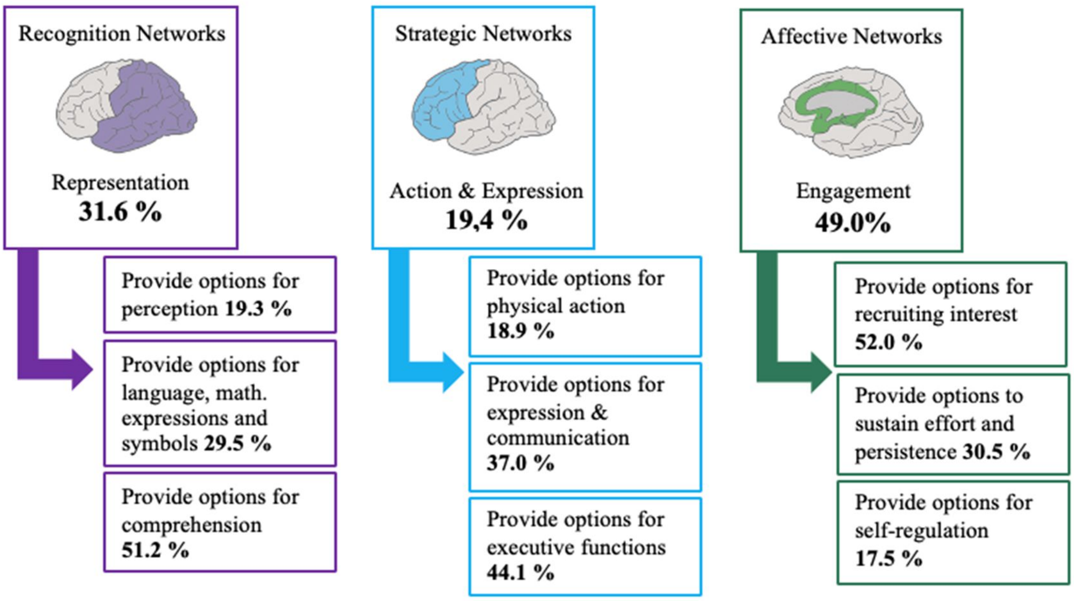

Figure 3. Distribution of codes in the written lesson plans on the UDL framework.

When it comes to written lesson plans, participants incorporate inclusive measures mainly through targeting the affective networks. The guideline "Provide options for recruiting interest" makes for half of the codes distributed for this principle and manifests itself through offering relevant and authentic lesson content closely related to the specific vocation. Around 30 % of the codes for the affective networks can be found in the guideline "Provide options to sustain effort and persistence", where prospective teachers plan to create a space of collaboration and community fostering motivation, e.g., when using scenarios that simulate what could happen at the workplace, employing methods to activate students and to reflect about their own experiences as well as collaborative methods. Following the affective networks, the second highest number of codes is reached in the recognition networks (31.6 %). Here, participants especially target the guideline "Provide options for comprehension", e.g., supporting students' comprehension processes through activating prior knowledge and guiding information processing. Furthermore, they facilitate understanding for students of all language levels and use visual aids (guideline: "Provide options for perception"). Other forms of representation and visualization for the recognition networks include methodological or content-related lists of criteria, Advanced Organizers that help students to keep track of topics and methods, using practical exercises (e.g., role-plays or training of job-specific handicrafts) and visual aids like posters, flipcharts and the black board. Only around 20% of all codes went to the strategic networks. Nevertheless, some participants plan to guide appropriate goal-setting through transparency of the lessons' aims and contents (guideline: "Provide options for executive functions") and use multiple media to address multiple learning types (guideline: "Provide options for expression and communication"). Examples from the lesson plans include clearly stating the topic and learning outcome of the lesson and giving a brief overview of the progression of the lesson, sometimes using visual tools. Some participants also plan to keep the grading process transparent for students. In addition, media used by the participants and offered to the students are among others: laptops and tablets, using a handwritten notebook as a memo technique, showing videos, visualizing handwritten documents by students through a smart cam or using a virtual classroom tool.

Further analyses revealed that participants with less experience, i.e., university students in their practical semester, integrated fewer measures of differentiation or individual support for students with an average of 16,3 codes. The average increases to 21,8 codes for pre-service teachers who have already served half their practical teacher training at a school and is the highest (24,6) for participants at the end of their practical teacher training program. Additionally, the descriptions of classes from the written lesson plans were analyzed wherever possible to take the actual heterogeneity into account. Three levels of heterogeneity were established based on the following characteristics: prior education, (prior) knowledge, language abilities and motivation to learn.

Table 1. Levels of heterogeneity and the number of codes on average.

Level 1: mostly homogeneous according to all characteristics (n=8)	Ø 16,25 codes
Level 2: heterogeneous, but few pupils with major difficulties and most are motivated to learn. (n=8)	Ø 18,75 codes
Level 3: very heterogeneous in all areas, difficult to motivate. (n=13)	Ø 24 codes

Table 1 shows an increase in codes on average for more heterogeneous classes, suggesting that the participants try to adapt their lesson planning to meet all students' needs.

From the large sample of lesson plans and participants' planning competences, a sub-sample (n=8) was taken to examine how the planned lessons translate into the classroom context. The sub-sample consists of four university students in their practical semester with the subject biotechnology and four pre-service teachers with the subject's biotechnology and chemistry. There are six female and two male participants, ranging between 25 and 37 years of age. Five test persons have a vocational background in the areas of medicine (medical-technical assistant and geriatric nurse), chemistry (chemical-technical assistant), biology (biological-technical assistant) and biotechnology (hairdresser). The coding manual was adapted to allow for quick and easy application in the classroom, leaving only the checkpoints without explicit subcodes. There was enough room for notes on each checkpoint. In the eight observations, a total of 150 codes was allotted with an average of 18.75 codes per lesson, the minimum of codes being 16 and the maximum 24. To recognize parallels between the distribution of codes for the written lesson plans and the observation of the lesson, the same figure as above was used:

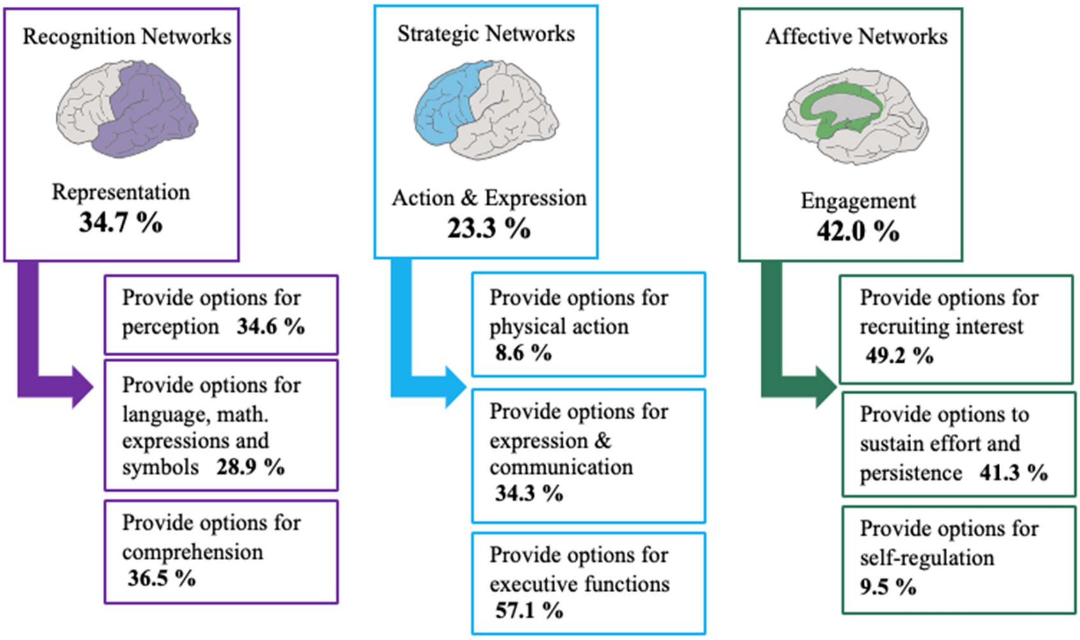

Figure 4. Distribution of codes for the lesson observations on the UDL framework.

The Affective Networks remain the strongest area with 42.0 % (49.0 % for the written lesson plans) combining the guidelines “Provide options for recruiting interest” (49.2% / 52.0 %) and “Provide options to sustain effort and persistence” (41.3 % / 30.5 %). A slightly lower percentage is reached for the guideline “Provide options for self-regulation” (9.5 % / 17.5 %). This last guideline manifests itself more in the written lesson plans than in the actual lessons. This is mainly due to a lack of time to implement thorough and effective methods of (self-)reflection in the lesson even when planning to do so in the lesson plan. Furthermore, efforts to integrate students’ opinions and observations through evaluation sheets (e.g., when observing a role-play) sometimes fall short of their initial appeal, when they end up being unstructured and too little acknowledged in the final discussion. In the lessons, different means of representation play an important role, which shows in the number of codes in the Recognition Networks (34.7 % / 31.6 %). Here, the distribution on the three guidelines is more balanced than in the written lesson plans. While “Provide options for comprehension” stays in first place code-wise (36.5 % / 51.2 %), the guideline “Provide options for perception” (34.6 % / 19.3 %) accumulates significantly more codes. The options for comprehension include the activation of prior knowledge at the beginning of the lesson, accompanying the students’ learning process and maximizing transfer and generalizations. In this case, the percentage of codes is again higher in the written lesson plans which can be explained by the plans of the prospective teachers to structure and accompany students' process throughout the lesson but managing only to do so at the beginning and sometimes after the introductory phase. The options for perception on the other hand, are more pronounced in the lesson observations, since the representation of information through font sizes, color contrasts or well readable writing on the board can to a large extent only be perceived in the actual lesson and to a lesser extent in the materials attached to the lesson plans. The least used measures for inclusive teaching stem from the Strategic Networks (23.3 % / 19.4 %), where physical action (8.6 % / 18.9 %), expression and communication (34.3 % / 37.0 %) as well as options for executive functions (57.1 % / 44.1 %) play a major role. The guideline "Provide options for physical action" is represented by the checkpoints "Learning materials and students' answers" as well as "Access to different resources". Both checkpoints manifest themselves more in the written lesson plans because the role-plays in the observed lessons were usually limited to two or four students, giving solely those the opportunity of expression through physical action. Furthermore, some digital tools, like QR-codes for links to further information on a topic are usually redundant since they are ignored by students. Additionally, student autonomy for presenting results is claimed in some lesson plans, but this is only true for decisions involving one medium, like videos and not the choice of any media desired by the students.

DISCUSSION AND OUTLOOK

In the analysis of 30 written lesson plans, all prospective teachers incorporated elements of the UDL-framework thereby making their teaching more accessible to a heterogeneous student body. Most frequently, they integrated methods of recruiting students' interest through relevant and authentic lesson contents. Results also show that more experienced prospective teachers use more methods of differentiation than less experienced teachers do. The same is true for the level of heterogeneity in a class: the higher the overall heterogeneity of a class, the higher the number of codes in the lesson plans. In the following lesson observations in eight classrooms, the prospective teachers' competences in conducting a lesson were documented. While the overall tendencies and distributions are similar in both cases, there are some differences worth considering: prospective teachers seem to struggle with limiting their lesson time to 45 minutes and incorporating everything they put forward in their written lesson plans, they sometimes lack the flexibility to make adjustments for better accessibility of their lesson and they use digital tools mostly without reflecting their advantages and disadvantages.

In addition to the findings above, the in-service teachers' interviews and students' questionnaires on each lesson will be considered. Further insights into the test persons' point of view will also be gained by analyzing the interview with each participant at the end of the study and their answers on the questionnaire of attitudes, self-efficacy and willingness towards inclusion.

REFERENCES

Al-Azawei, A., Serenelli, F. & Lundqvist, K. (2016). Universal Design for Learning (UDL): A Content Analysis of Peer-Reviewed Journal Papers from 2012 to 2015. Journal of the Scholarship of teaching and Learning. 16: 3, 39-56. DOI: 10.14434/josotl.v16i3.19295

Amrhein, B. (2011). *Inklusion in der Sekundarstufe: Eine empirische Analyse*. [Inclusion in the lower secondary level school: an empirical analysis]. Klinkhardt Forschung. Bad Heilbrunn: Klinkhardt.

APO-BK (Ausbildungs- und Prüfungsordnung für Berufskollegs des Landes Nordrhein-Westfalen) Bildungsziele des Berufskollegs. 2019 (NRW). Chapter 1.1 (Germany). [Apprenticeship and Examination Regulations for vocational schools in North-Rhine-Westphalia].

Capp, M. J. (2017). The effectiveness of universal design for learning: a meta-analysis of literature between 2013 and 2016, International Journal of Inclusive Education, 21:8, 791-807, DOI: 10.1080/13603116.2017.1325074

CAST (2018). Universal Design for Learning Guidelines version 2.2. Retrieved from URL: http://udlguidelines.cast.org (last accessed: 21.07.2021)

Euler, D. & Severing, E. (2016). Inklusion in der beruflichen Bildung. Daten, Fakten, offene Fragen [online]. [Inclusion in vocational education. Data, facts and open questions]. URL: https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/

Gillen, J. & Wende, J. (2017). Inklusion in der beruflichen Bildung – Status Quo, Konsequenzen und Potenziale für Forschung und Lehre [Inclusion in vocational education and training – status, consequences and potential for research and teaching]. Available from: https://www.inklusion-online.net/index.php/inklusion-online/article/view/445/330

Heinrichs, K. & Reinke, H. (Hrsg.) (2019). Heterogenität in der beruflichen Bildung. Im Spannungsfeld von Erziehung, Förderung und Fachausbildung. [Heterogeneity in Vocational Education. In the crossfire of education, encouragement and apprenticeship. Reihe Wirtschaft - Beruf - Ethik, wbv-Verlag. Available from: https://www.researchgate.net/publication/335977098_Heterogenitat_in_der_Berufsbildung_Im_Spannungsfeld_von_Erziehung_Forderung_und_Fachausbildung.

Hymel, S. & Katz, J. (2019). Designing Classrooms for Diversity: Fostering Social Inclusion. Educational Psychologist, 54:4, 331-339. DOI: 10.1080/00461520.2019.1652098.

Lambe, J. & Bones, R. (2006). Student teachers' perceptions about inclusive classroom teaching in Northern Ireland prior to teaching practice experience. In: European Journal of Special Needs Education, Vol. 21 (2), pp. 167-186.

Meyer, A., Rose, D. H. & Gordon, D. (2014). *Universal Design for Learning*. Theory and Practice. Wakefield: CAST.

Reich, K. (2018). Inklusive Bildung in Deutschland umsetzen. [Implementing inclusive education in Germany]. Edited by the German UNESCO commission. Available from: https://www.unesco.de/publikationen?page=10#row-2205

Schlüter, A.-K. (2018). *Professionalisierung angehender Chemielehrkräfte für einen Gemeinsamen Unterricht.* [Professionalisation of prospective chemistry teachers for inclusive teaching]. Studien zum Physik- und Chemielernen. Band 257. Berlin: Logos.

Smith, A. & Bell, S. (2015). Towards Inclusive Learning Environments (TILE): Developing the 'Roadmap for the Inclusion of Students with Special Educational Needs in Vocational Education and Workplace Settings'. In: Support for Learning (SfL) NASEN, Vol. 30 (2), pp. 150-160.

Spooner, F., Baker, J.N., Harris, A.A., Ahlgrim-Delzell, L. & Browder, D.M. (2007). Effects of Training in Universal Design for Learning on Lesson Plan Development. In: *Remedial and Special Education*, *Vol. 28 (2),* pp.108-116.

UNESCO (United Nations Educational, Scientic and Cultural Organization). (2020). Towards inclusion in education: Status, trends and challenges. The UNESCO Salamanca Statement 25 years on. Available from: https://unesdoc.unesco.org/ark:/48223/pf0000374246.

United Nations (2008). UN- Convention on the Rights of Persons with Disabilities (CRPD). Available from: https://www.un.org/development/desa/disabilities/convention-on-the-rights-of-persons-with-disabilities/convention-on-the-rights-of-persons-with-disabilities-2.html

MAPPING RURAL PRIMARY SCHOOL STUDENTS' SELF-POSITIONING IN RELATION TO SCIENCE

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Students from rural areas are underrepresented in the fields of science and technology. This underrepresentation is associated with the incompatibility between the cultural perspective of science and their local community culture. Drawing from relevant literature on positional identity the present study aims to map rural primary school students' self-positioning in relation to science and its development through the interaction with agricultural scientists. Twenty three 5^th^ to 6th grade students from a semi-mountainous rural village of Crete participated in this case study. Data collected through students' artifacts and interviews indicate that rural students possess important funds of technical knowledge through the agrarian activities they engage with, however they themselves don't perceive that knowledge as compatible with school science. However their interaction with agricultural scientists who acted as role models contributed in confining the stereotypical characteristics students held for science and scientists and in bridging the seemingly incompatible contexts of local culture and science.

Keywords: Science and Culture, Primary School, Equity

INTRODUCTION

Science and technology are now integrated into modern society to such an extent that it is necessary, from a social and political point of view, for citizens to possess basic scientific knowledge but also to be able to make informed decisions on both every day and wider societal issues. Given this, equity in access and engagement of all students (regardless of gender, cultural or social background) with science is a critical issue (Bianchini, 2017). However, girls and students from non-dominant cultural and low economic background, are underrepresented in the fields of science and technology (McGee & Bentley, 2017). Growing research evidence supports that this underrepresentation is associated with the incompatibility between the cultural perspective of science and the community culture (in other words the norms, values and conventions) of the aforementioned groups (Archer et al., 2010) and directly affects the ability of students to identify themselves as science-persons and build their scientific identity.

Based on Carlone & Johnson's (2007) approach to students' scientific identity, the construct involves three overlapping dimensions: competence, performance, and recognition. Competence describes one's capacity to understand scientific information, performance is related to one's capacity to appropriately engage in scientific activities while recognition refers to one's opinion of oneself as a "science person," and others' perceptions of oneself as a "science person". This model's three aspects openly relate how students navigate our society's cultural norms to develop science identities.

According to the theoretical framework of cultural border crossing (Aikenhead, 2001) the incompatibility between the cultural perspective of science and community culture rises cultural borders that students have to cross in order to engage with science-related activities. However, the fact that a local culture may differ from that of science or school science doesn't mean that this culture is deprived of funds of knowledge that can be utilized as valuable resources in the context of science culture (Seiler, 2013).

Focusing specifically on students from rural areas, research shows that they exhibit higher rates of school dropout and follow less frequently science professions in comparison with urban students (Young, 2000). Nevertheless, at the same time rural science education research highlights the fact that many elements of local rural knowledge may be used as funds of knowledge for science learning (Avery, 2013) encompassing farming and agriculture activities.

Therefore, given the need to strengthen rural students' science identity, as a means to enhance their overall engagement with school science, this work is part of a larger project that studies the factors that act upon the development of rural students' science identity. Drawing from relevant literature on positional identity (Rahm, 2008) and taking into account previous research that employs scientists as role models for this purpose (Kenneth Jones & Hite, 2020), this paper examines how rural primary school students self-identify with science and explore the potential of students' interaction with scientists – experts on topics related to their rural daily life, as a means of enhancing aspects of their scientific identity. The research questions that guide this study are:

(i) What are rural primary students' perceptions of science and scientists?
(ii) What are rural primary students' perceptions of themselves in relation to science?
(iii) What are rural primary students' perceptions of their participation in science-related activities?
(iv) How do these perceptions evolve through students' interaction with agricultural scientists?

METHOD

Context of the study & Participants

The methodology used for this research study lies within the tradition of ethnographic case studies. The study took place in a village of about 600 residents in a semi-mountainous rural area of Crete. In this area the main occupation of the residents is farming, dairying, agriculture and vinification. Children from an early age participate in the agrarian activities of their parents. The local culture requires boys usually to follow the family occupation and the girls to marry and start a family at a much younger age compared to their urban peers. Moreover, the administrative district where the school belongs has the highest nationwide student dropout rate from high school (10th to 12th grade) according to the latest report of the Greek Institute of Educational Policy (2019).

The local primary school, where the researcher also worked as a teacher during the school year 2021-2022, hosts in total 70 students. The participants in this study were 23 students (10 girls and 13 boys) from 5th and 6th grade.

The scientists selected to interact with the students were a biologist postdoctoral researcher in the Laboratory of Plant Biomolecules and Biotechnology at the University of Tours on the field of oenology and processing of vines with biostimulants and an agronomist researcher and lecturer on Agricultural Engineering and Soil Microbiology.

Research design

At first, during the orientation phase, the driving question of "How can we improve the agricultural production of our area?" was posed and the students were invited to turn to the local community, in order to collect the relative problems their community faced and the questions that they would like to ask a specialist.

Afterwards, two 90-minute tele-meetings with the scientists took place who, having been informed about the aims of the current research, were asked to prepare a brief presentation of their research field with emphasis on its usefulness in agricultural production. The students also had the opportunity to ask them about possible solutions to their community's problems as well as about more personal and social aspects of their daily lives as scientists.

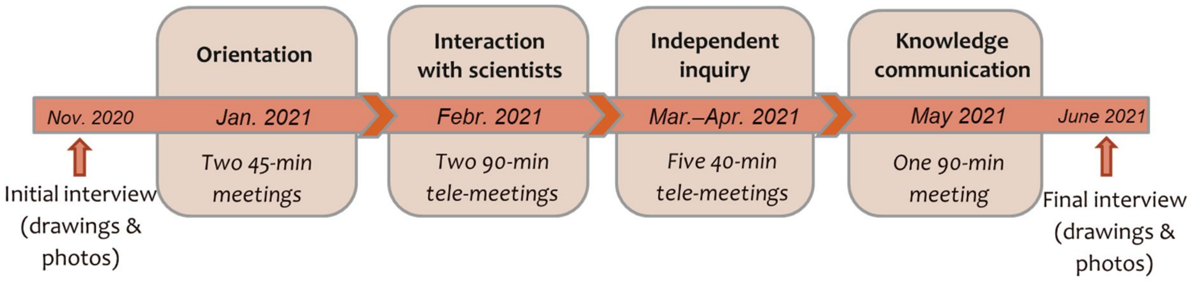

Figure 1. Overview of the students' process.

Students were then guided through webquests in search of more information on the issues raised during the discussions with the scientists and their findings were discussed during five 40-minute on-line meetings.

Finally, the students shared with their local rural community the findings of their research and key-elements of their discussion with the scientists through posters and an on-line event where students, their families and members of the local authority took part.

Data collection and analysis

For the purpose of our study, a multidimensional data collection was carried out using different collection methods that contribute to a more thorough understanding of students' self-positioning towards science as well as to greater validity and reliability of the research findings.

At first, before the orientation phase, we administered a variation of the "Draw A Scientist Test". Students were also called to take photographs of what they believe constitutes a scientific activity in their everyday life.

Then interviews in groups of three took place which were assisted by the aforementioned artifacts and allowed us (i) to clarify details on the students' drawings and the respective perceptions of scientists and scientific activities, (ii) to discuss their identification with their perceived image of science and scientists and their interest in following a science-related occupation, (iii) to elaborate further on the perception of their participation in science related activities in their everyday lives by discussing on the photos they took and on presented images of farming, dairying, agriculture and vinification activities. Similar interviews assisted by new students' sketches of scientists and photos of scientific activities were also conducted after the completion of the program.

Moreover, on-line and face-to-face students' meetings with the teacher/researcher and the scientists were also audio-recorded. Information regarding students' personal and family background were collected through the researcher's participatory observation and her interactions with their parents throughout the school year.

Qualitative methods of content analysis were employed to analyze the data from various sources. Data analysis was based on Carlone & Johnson's (2007) conceptualization of science identity as well as on STEM identities theoretical model of Kang et al. (2019) according to which students' identities are formed through constructs as their personal and familial background, their participation in science-related activities, their perceptions about self, science, and scientists' work and their interest in following a science-related job.

Transcriptions of the interviews constituted the main data set. Hence, data from students'-teacher's conversations during the meetings were used to crosscheck the themes that emerged during the analysis of the main data set. Afterwards, the transcriptions were read repeatedly and examined in terms of students' conceptualization for scientists & science, their self-perception of their performance and competence in science, their self-recognition as science persons and their scientific ambitions.

RESULTS

Students' initial drawings and follow-up interviews revealed that rural primary students held stereotypical perceptions of scientists. In most of their drawings scientists were presented as white, middle-aged men, with white lab coats and eyeglasses, conservative, untidy appearance and serious face expression, in the foreground of a laboratory with bottles, test tubes and organization folders. During the follow-up discussions, perceptions of scientists as important, prestigious but at the same time lonely, familyless individuals came upon. At this point it bears mentioning that solitary life, not having children and diverging from housewife/fatherly duties are characteristics radically opposed to the local culture's values and are attributed a negative connotation. Students' final drawings and interviews, after the completion of the program, revealed a mitigation of stereotypical features of scientists. Moreover, while scientists continued being perceived as prestigious persons, they were now described as more familiar figures with common interests and social life as theirs.

Regarding their self-perceptions on aspects of their science identity, rural students' perceptions on their competence weren't significantly altered and continued in their majority to underline a difficulty in understanding science concepts and to characterize themselves as not particularly academically successful in science classes. On the other hand, their perceptions on their science performance seamed to develop through the program. Initially, their photos of scientific activities depicted in their majority school laboratory equipment and secondarily technological applications/ products they use such as cars, mobile phones, video games consoles etc. In the interviews that followed they stated that they were not frequently involved in science-related work outside of school. When they were presented with photographs depicting tasks such as making yogurt, distilling raki and wine fermentation, they could describe the processes almost accurately (especially the older students) but without any scientific explanation or terminology. Furthermore, they did not recognize in any case that these activities could be related to aspects of science. After their interaction with the scientists and their investigation on the topic, the majority of the students recognized aspects of their community's agricultural work as relevant to science and conversely, they recognised agricultural science as relevant and useful for their community's activities. Finally, as regards their (self-)recognition as science persons, the majority of students after the program continued not identifying their selves as "belonging" to science however more than half of the them declared they felt like being recognised as potential future scientists by their parents after the communication of science-based solutions to the community's agricultural problems, as a result of their discussion with the scientists and the autonomous investigation they conducted on these issues.

As regards their scientific professional ambitions, rural students found science interesting and important to society in general, however initially they couldn't trace its importance for them personally. Moreover, the vast majority of the students stated that they couldn't imagine themselves being a scientist in the future as that would mean that they would have to study all the time, instead of being occupied with their own interests and creating a family. However, after the completion of the program more students started conceiving science as useful for their local community and for the improvement of the agricultural production of their area and considered engaging professionally with science as a more possible outcome than before.

DISCUSSION AND CONCLUSIONS

Rural students' initial perceptions of scientists were consistent with the results of respective studies in terms of their appearance and lifestyle (e.g., Kenneth Jones & Hite, 2020) and therefore they shared very few characteristics compatible to their local culture and values. At the same time, through the apprenticeship in their family's occupation, students had developed a technical know-how for many scientific activities that may serve as a very useful fund of knowledge for science learning. However, they themselves didn't recognize this kind of knowledge as congruent with science or school science, ending-up positioning themselves as outsiders in science (Avraamidou, 2020). Hence, the development of teaching approaches that integrate and give prominence to this fund of knowledge (e.g., Borgerding, 2017) and present students with suitable science role-models was required, in order to contribute to the development of scientific identity of rural students.

In such an attempt, in our research we employed agricultural scientists as role models and engaged students in searching for scientific solutions to their rural community's problems with their assistance. From our evidence derives that (i) the utilization of knowledge from the local context in the context of science, (ii) the proof of the usefulness of scientific knowledge in solving everyday agricultural problems and (iii) specific characteristics of the scientists that acted as role-models had an effect on rural students' identification with science. Particularly, those elements contributed in confining the stereotypical characteristics students held for science and scientists and gave prominence to the value of scientific knowledge to students' everyday life helping in this way to bridge the two seemingly incompatible contexts of local culture and science that rural students were called to respond to.

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REFERENCES

Aikenhead, G. S. (2001). Student's ease in crossing cultural borders into school science. *Science Education, 85*, 180-188.

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education, 94*(4), 617-639.

Avery, L. (2013). Rural science education: Valuing local knowledge. *Theory into Practice, 52*, 28–35.

Avraamidou, L. (2020). Science identity as a landscape of becoming: Rethinking recognition and emotions through an intersectionality lens. *Cultural Studies of Science Education, 15*(2), 323-345.

Bianchini, J. A. (2017). Equity in science education. In K. S. Taber & B. Akpan (Eds.), *Science education* (pp. 455–464). Rotterdam: Sense Publishers.

Borgerding, L. A. (2017). High school biology evolution learning experiences in a rural context: a case of and for cultural border crossing. *Cultural Studies of Science Education, 12*(1), 53-79.

Institute of Educational Policy. (2019). *Η μαθητική διαρροή στην ελληνική πρωτοβάθμια και δευτεροβάθμια εκπαίδευση* [Student dropout in Greek primary and secondary education]. Retrieved from: http://www.iep.edu.gr/images/IEP/EPISTIMONIKI_YPIRESIA/Epist_Grafeia/ekthesi_diarrois_2014-2017.pdf

Kang, H., Calabrese Barton, A., Tan, E., D Simpkins, S., Rhee, H. Y., & Turner, C. (2019). How do middle school girls of color develop STEM identities? Middle school girls' participation in science activities and identification with STEM careers. *Science Education*, *103*(2), 418-439.

Kenneth Jones, L., & Hite, R. L. (2020). Who wants to be a scientist in South Korea: assessing role model influences on Korean students' perceptions of science and scientists. *International Journal of Science Education, 42*(16), 2674-2695.

McGee, E., & Bentley, L. (2017). The equity ethic: black and Latinx college students reengineering their STEM careers toward justice. *American Journal of Education, 124*(1), 1–36.

Rahm, J. (2008). Urban youths' hybrid positioning in science practices at the margin: A look inside a school–museum– scientist partnership project and an after-school science program. *Cultural Studies of Science Education, 3*(1), 97–121.

Seiler, G. (2013). New metaphors about culture: Implications for research in science teacher preparation. *Journal of Research in Science Teaching, 50*, 104–121.

Young, D. J. (2000). Rural and urban differences in student achievement in science and mathematics: A multileveled analysis. *School Effectiveness and School Improvement, 9*, 386–418.

THE ROLE OF LANGUAGE IN THE DEVELOPING UNDERSTANDING OF "ANIMAL": INSIGHT FROM SINGAPOREAN CHILDREN

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The formation of explicitly expressible conceptions begins early in the developmental trajectory such that by the age of 3 years children exhibit ideas that are incommensurate with accepted scientific views. Because of their early emergence, they tend to be highly resistant to change through instruction. An important factor in the development of these conceptions is language, both in terms of the use of language to express ideas and in terms of the formative linguistic environment through which knowledge is abstracted. One concept central to scientific learning is the animal, specifically about understanding what is an animal and what is not. Various studies have demonstrated that children's understanding of this concept emerges very early in development and is subject to changes over time through formal and informal instruction. However, they also demonstrate that this understanding also varies across linguistic contexts – children express different archetypal definitions of "animal" depending on the language they speak. Yet, there is a lack of understanding what impact multilinguistic exposure may have on the formation of such understanding, especially where the language of instruction differs from the language primarily spoken in the home environment – as is the case for a substantial number of children in Singapore. The multilingual exposure might strengthen their understanding, providing an advantage over monolingual children, but might equally lead to greater difficulty in overcoming misconceptions. This presentation will report on findings of a cross-sectional study conducted with children aged 4, 7 and 10, towards the aim of expanding our current understanding of scientific knowledge construction across early and middle childhood, and to subsequently contribute to further development of pedagogy across a range of relevant contexts.

Keywords: Conceptual development; elementary science; language

INTRODUCTION

Brief Literature Review

Scientific conceptions are often underpinned by the interpretation of everyday world experiences – even before children enter formal science learning contexts. These are formulated through experiences and discourses in everyday contexts and can result in wide range of preconceived scientific ideas about how the world works (Hast, 2014) and are based on unique experiences of those everyday contexts (Bliss, 2008), so ideas vary widely, in terms of content and degree of understanding. Many preconceived ideas are incommensurate with accepted scientific views and with the concepts that are, as a result, taught within classroom settings and are often found to be highly resistant to change through instruction, affecting subsequent learning of related concepts (Duit et al., 2013). This can pose a challenge for learners trying to organise their own conceptions, but also for teachers who need to organise that wide range of conceptions within a single shared educational setting. One of these foundational concepts is "animal".

Various studies have demonstrated that children's understanding of "animal" emerges very early in development and is subject to changes over time through formal and informal instruction. The general ability to form categories appears early in life, at least from two months of age onwards (Westermann & Mareschal, 2014), and even young infants demonstrate capacity for determining whether something is a living being or not (Träuble & Pauen, 2011), or that some animals are different from others (Furrer & Younger, 2005). But as language plays a more crucial part in interpreting the world, children seem to develop more archetypal definitions of animals. Three-year-olds appear to possess slightly less archetypal definition of "animal" than 5-year-olds do (Allen, 2015), which would correspond to the suggestion that an explicit formation of scientific misconceptions begins to show first signs before 3 years of age (Hast, 2018, 2019; Mandler, 2004), with the development of language playing a key role in the generation of such conceptions. Beyond this early stage, a range of studies in different linguistic contexts has demonstrated there is subsequently no single archetypal definition for the "animal" category in later development.

The Singapore Context

The Singaporean syllabus for primary science education requires students to learn about "living and non-living things" (Ministry of Education, 2014, p. 41), making specific reference to animals and their subgroups. This is a topic that is typically only covered in Primary 3 and Primary 4 (ages 8-10 years). But scientific concepts can already be deeply entrenched even by the time children begin formal education, often clashing with the accepted scientific viewpoints, including about animals. However, there is a lack of understanding what impact multilinguistic exposure may have on the formation of such understanding, especially where the language of instruction differs from the language primarily spoken in the home environment, which is the case for most children in Singapore. While the language of instruction in public schools in Singapore is English, there are four official languages in the country: English, Mandarin, Malay, and Tamil. And almost two thirds of Singaporean households speak a language other than English (Department of Statistics, 2016).

Problem Statement

Research has evaluated the development of children's understanding of the concept "animal" in the context of other languages, including Mandarin. However, there have been no direct language comparisons within studies. Allen (2015) does argue in his paper that the Mandarin *dòngwù* provides similar parameters to its users as "animal" does in English, but this is not entirely clear and can only limitedly be deduced across studies rather than being evaluated within individual children. Even a simple comparison of English and Mandarin studies would not give insight into this project's core matter of concern. Further, in existing studies, languages were always first language as well as language of instruction. Yet how is conceptual understanding impacted by exposure to more than one language? Do Singaporean children understand "animal" differently based on language – both across and within population groups? Does multilingual exposure provide a more coherent understanding of "animal" or does it present additional barriers to conceptual change?

Research Questions

Based on the lack of insight into cross-linguistic development of "animal", the study addressed two key research questions:

1) What is the relationship between understanding of “animal” in language of instruction and in language spoken at home?

2) How does children’s monolingual and multilingual understanding of “animal” develop over time?

THE STUDY

A total of 312 children aged 4, 7 and 10 years took part in a cross-sectional examination. Children came from four different home language (HL) groups according to which language was most frequently spoken in their home environment – English, Mandarin, Malay, and Tamil. Each of the 12 overall groups (age x HL) consisted of an equal number of children. Using an online survey format, children were shown images of animals and non-animals, and they were required to decide whether the images showed an animal or a non-animal (see Figure 1 below). They completed tests in English as well as in their HL where English was not their HL. Tests were counterbalanced so that half of the children in each group completed the English version first and the other half the HL version first.

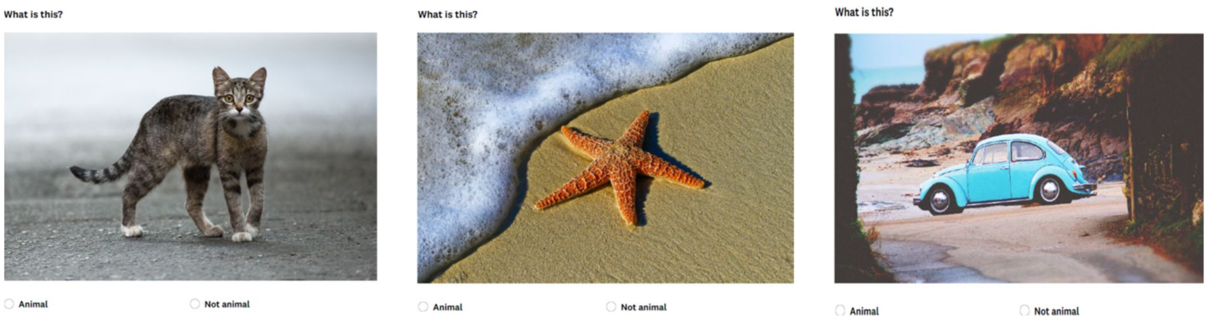

Figure 1. Examples from English version task, showing archetype animal (left), non-archetype animal (centre) and non-animal (right).

SUMMARY OF RESULTS

Correct recognition of non-animals was, as expected, very strong. When examining performance across the English tests, Malay-speaking children performed significantly better than all other three groups for all animals overall as well as for non-archetypal animals, but not for archetypes. The other three groups did not show significant variation. When examining performance across the different HLs, again Malay-speaking children performed better than all other three groups on all animals and on non-archetypal animals, but not for archetypes. Finally, while Mandarin- and Tamil-speaking children’s performances did not differ significantly between English and HL tests, Malay-speaking children performed significantly better on the HL version than the English version. Out of the four languages, Malay has the broadest archetypal definition of “animal” that only excludes humans. As a result, it is perhaps not surprising that the Malay group showed a significantly higher correct score for non-archetypal animals than the remaining groups. Thus, home language exposure that has broader definitions may strengthen a child’s understanding when also learning in the context of a different instructional language.

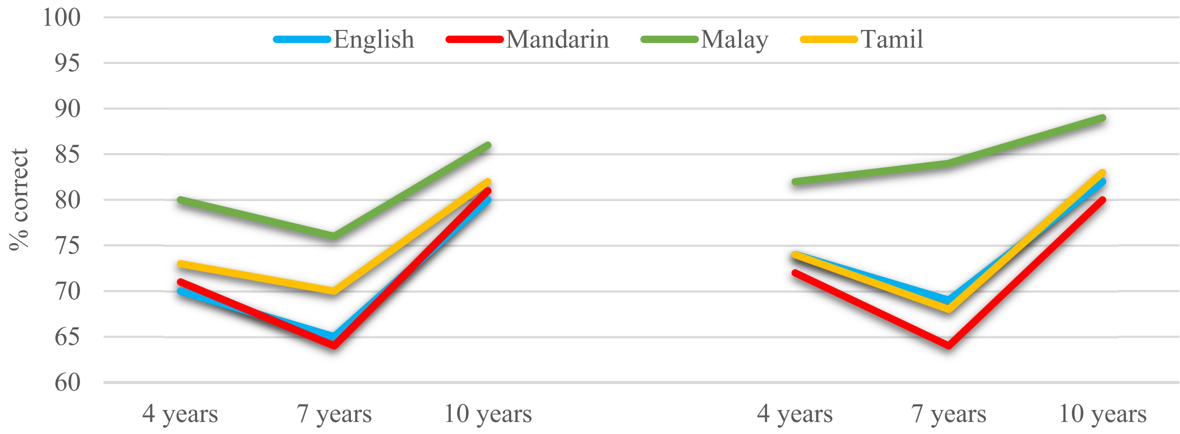

Figure 2. Performance across English version tests (left) and across different HLs (right).

Age-wise, both analysis sets showed the oldest children consistently performing significantly better than both the 4- and the 7-year-olds, but no significant differences between the two younger groups. Nonetheless, patterns emerging suggest a U-shaped performance curve, with 4-year-olds mostly scoring slightly higher, on average, than 7-year-olds. This seems to be in line with the suggestion that archetypal definitions begin to emerge around 3-4 years of age. The notable exception was again the Malay-speaking group, which did not follow the same U-shape trend. The older children's significantly improved performance can be associated with educational experience as their testing occurred after having been taught about animals in school, as per the national syllabus.

LIMITATIONS

The study brought forward some limitations in its scope for conclusion. First, the results illustrate a linguistic effect for only one specific scientific concept. Further studies will need to consider a broader range of scientific domains to examine for consistency of the current observations. Second, the study does not offer qualitative insight into children's understanding of "animal". However, such an understanding might show a more nuanced cross-linguistic differentiation. Third, the study required an explicitly expressed understanding of animal. Studies in other domains have shown children's expressed ideas may differ from their underlying understanding of the same ideas, which can be more accurate (e.g., Hast & Howe, 2015, 2017; also cf. Hast, 2020). Examining an underlying awareness of "animal" might provide more detailed insight into conceptual development role played by language.

CONCLUDING REMARKS

Overall, the study may have a variety of implications for understanding the role of language in the formation of scientific concepts as well as for instructional approaches. For instance, similar to the Finnish inter-disciplinary teaching and learning approach that addresses transversal competences (Lavonen, 2020; Vahtivuori-Hänninen et al., 2014), the role of Mother Tongue classes in Singaporean schools could find a new role in the context of scientific pedagogy. In turn, scientific literacy may be a way to support Mother Tongue learning as well. Beyond Singapore, the findings may lead to more careful consideration of pedagogy in increasingly diverse classrooms due to globalisation and global migration as a direct result of dispersion following recent conflicts. Finally, an important implication is that generating a stronger understanding of how the specific concept "animal" develops could potentially impact areas around conservation and pro-environmental behaviour (Cornelisse & Sagasta, 2018; Melis et al., 2020). For instance, recognising that invertebrates, generally viewed negatively, fall under same umbrella "animal" as more endearing species, such as mammals, can improve attitudes towards them, even in pre-schoolers (Borgi & Cirulli, 2015).

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REFERENCES

Allen, M. (2015). Preschool children's taxonomic knowledge of animal species. *Journal of Research in Science Teaching, 52*(1), 107-134.

Bliss, J. (2008). Commonsense reasoning about the physical world. *Studies in Science Education, 44*(2), 123-155.

Borgi, M., & Cirulli, F. (2015). Attitudes toward animals among kindergarten children: Species preferences. *Anthrozoös, 28*(1), 45-59.

Cornelisse, T. M., & Sagasta, J. (2018). The effect of conservation knowledge on attitudes and stated behaviors toward arthropods of urban and suburban elementary school students. *Anthrozoös, 31*(3), 283-296.

Department of Statistics (2016). *General household survey 2015*. Singapore: MTI.

Duit, R., Treagust, D. F., & Widodo, A. (2013). Teaching science for conceptual change: Theory and practice. In S. Vosniadou (Ed.), *International handbook of research on conceptual change* (pp. 487-503). London: Routledge.

Furrer, S. D., & Younger, B. A. (2005). Beyond the distributional input? A developmental investigation of asymmetry in infants' categorization of cats and dogs. *Developmental Science, 8*(6), 544-550.

Hast, M. (2014). Collaborating with the 'more capable' self: Achieving conceptual change in early science education through underlying knowledge structures. *ReflectED, St Mary's Journal of Education, 3*, 18-25.

Hast, M. (2018). It's all relative: The role of object weight in toddlers' gravity bias. *Journal of Experimental Child Psychology, 166*, 696-704.

Hast, M. (2019). Representational momentum in displacement tasks: Relative object weight matters in toddlers' search behaviour. *International Journal of Behavioral Development, 43*(2), 173-178.

Hast, M. (2020). "It is there but you need to dig a little deeper for it to become evident to them": Tacit knowledge assessment in the primary science classroom. In C. Koh (Ed.), *Diversifying learner experience: A kaleidoscope of instructional approaches and strategies* (pp. 13-28). Singapore: Springer.

Hast, M., & Howe, C. (2015). Children's predictions and recognition of fall: The role of object mass. *Cognitive Development, 36*, 103-110.

Hast, M., & Howe, C. (2017). Changing predictions, stable recognition: Children's representations of downward incline motion. *British Journal of Developmental Psychology, 35*(4), 516-530.

Lavonen, J. (2020). Curriculum and teacher education reforms in Finland that support the development of competences for the twenty-first century. In F. M. Reimers (Ed.), *Audacious education* *purposes: How governments transform the goals of education systems* (pp. 65-80). Cham: Springer.

Mandler, J. J. (2004). Thought before language. *TRENDS in Cognitive Sciences, 8*(11), 508-513.

Melis, C., Wold, P.-A., Billing, A. M., Bjørgen, K., & Moe, B. (2020). Kindergarten children's perception about the ecological roles of living organisms. *Sustainability, 12*(22), 9565.

Ministry of Education (2013). *Science syllabus primary*. Singapore: MOE.

Träuble, B., & Pauen, S. (2011). Infants' reasoning about ambiguous motion events: The role of spatiotemporal and dispositional status information. *Cognitive Development, 26*(1), 1-15.

Vahtivuori-Hänninen, S., Halinen, I., Niemi, H., Lavonen, J., & Lipponen, L. (2014). A new Finnish national core curriculum for basic education (2014) and technology as an integrated tool for learning. In H. Niemi, J. Multisilta, L. Lipponen & M. Vivitsou (Eds.), *Finnish innovations and technologies in schools: A guide towards new ecosystems of learning* (pp. 21-32). Rotterdam: Sense Publishers.

Westermann, G., & Mareschal, D. (2014). From perceptual to language-mediated categorization. *Philosophical Transactions of the Royal Society B: Biological Sciences, 369*(1634), 20120391.

PROMOTING GIRLS IN OUT-OF-SCHOOL SCIENCE LABS AFTER THE TRANSITION FROM PRIMARY TO SECONDARY SCHOOL

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The underrepresentation of women in science and the increasing shortage of skilled workers in STEM are still evident. To counteract this trend, extracurricular programs in out-of-school science laboratories have been implemented to foster girls' interest in science and in a science oriented-career. Compared to boys of the same age, girls with equally high science competencies, an identical motivation to learn, and a positive ability self-concept are reluctant to imagine deciding for science-oriented careers. Furthermore, girls' interest in STEM careers decreases during secondary school. Accordingly, this exemplary case study focuses on current challenges of a chosen out-of-school science lab regarding the addressing of girls in science and therefore its impact on gender in the context of science education after the transition to secondary school. Data is collected by episodic interviews with management and staff members as well as qualitative field observations. To analyse the episodic interviews in-depth the documentary method is conducted. The complementary qualitative analysis of the field observations is based on content analysis. Based on the results, previous evidence and current theory, a tailor-made program, which promotes girls after the transition from primary to secondary school, is developed following design-based research. In view of investigated science programs in out-of-school laboratories on secondary level, this study helps to identify valuable advice about how programs should be designed and run to actively promote girls after the transition to secondary school. Hence, this exemplary case study will provide a solid basis for following studies which further promote gender equity in out-of-school science education.

Keywords: Non-formal Learning Environments, Science Education, Gender Issues

INTRODUCTION

Over recent decades, more women acquired STEM qualifications and embarked on STEM careers. Thus, significant progress towards gender equity in STEM has been achieved in many countries (American Association of University Women (AAUW), 2010; Archer et al., 2013). Although an androgynous, science stereotype slowly developed over the last fifty years (Miller, et al., 2018), beliefs about gender-specific interests and competencies still have a negative impact on young women's science self-concept (McNally, 2020). Gender gaps still prevail in multiple STEM fields worldwide, especially in computer science and engineering (Master, 2021; Stoet & Geary, 2018, 2020). Focusing on the German context in particular, this international status quo is apparent in view of taking up studies in computer science, electrical engineering, and nautical science, as well as completing a generally STEM-oriented apprenticeship (Federal Employment Agency statistics, 2019). Based on recent evidence, neither the performance nor the competence of women justify their exclusion from various STEM professions; however, gender differences in preferences and choices are involved (Haffner & Loge, 2019; Dasgupta & Stout, 2014). According to international data on adolescent achievement, girls obtained similar or better results in science than boys in two out of three countries and, additionally, more girls, than enrolled, appeared to be capable of STEM on college-level in almost every country (Stoet & Geary, 2018, 2020). At the end of lower secondary school in Germany, girls achieve significantly better results and higher competence scores in science subjects than boys (Schipolowski et al., 2019). Nevertheless, even girls with equally high science competencies, an identical motivation to learn, and a positive ability self-concept as boys of the same age are reluctant to imagine entering a science-oriented profession (Wieselmann et al., 2020). Regarding the higher percentage of girls, who would like to be successful in STEM and enjoy corresponding study fields than the propensity of women graduating in STEM, many girls internationally lose STEM related career aspirations between secondary and tertiary education (Stoet & Geary, 2018, 2020). Consequently, this decrease might be partially caused by strong stereotypes regarding STEM fields, which are not only favoring boys, but also erecting barriers for girls against STEM-oriented careers (Master & Meltzoff, 2020). Master and Meltzoff (2020, p. 161, original emphasis) differentiate between "stereotypes about *interest*/cultural fit" and "stereotypes about *ability*", which, as they are combined, may cause worries of women concerning the lack of ability both identifying themselves with STEM representatives and succeeding in STEM. Referring to equity and gender within context of education outcomes, men's and women's different career choices are often made early in life (Schleicher, 2019). OECD (2019) exposed that across 67 countries the gender gap in STEM studies is already evident among 15-year-old teenagers. In Germany, girls more often choose linguistic subjects, while boys tend to choose scientific subjects already in school. These preferences persist beyond vocational training and result in a distinction between men's and women's occupations (Haffner & Loge, 2019) as well as aggravating the shortage of skilled workers in several STEM fields. "[Narrowing these gender gaps] requires concerted efforts by parents, teachers and employers to become more aware of their own conscious or unconscious biases so that they give girls and boys equal chances for success at school and beyond" (Schleicher, 2019, p. 32).

To counteract that growing lack of STEM workers in Europe and strengthen the motivation of women for a STEM-oriented career, extracurricular science laboratories have been implemented to promote young people in science (Hausamann, 2012). Without performativity and accountability, conventional education is characterized with (Stocklmayer et al., 2010), out-of-school laboratories play a major role as an educational supplement alongside school to both inform and inspire the youth about science (Ralle, 2020; Dawson, 2019). On site, children and teenagers should not only be encouraged to actively engage with scientific and technical issues and methods, but also gain authentic insights into STEM professions. Therefore, out-of-school learning environments mostly focus on experience-based learning to make STEM tangible through independent, experimental activities and projects (Euler et al., 2015). Young people can be supported to develop science identities by giving them opportunities to leverage their lived experiences as well as shared community wisdom while they are doing science. Additionally, receiving recognition for it is likewise important (Calabrese & Tan, 2018). The value of extracurricular science environments consequently lies in assets-based and participatory approaches, "which seek to respect and value youth and community knowledge and resources" (Archer et al. 2021, p. 168). Since extracurricular programs at the labs are made to adequately fulfil kids' and teenagers' individual learning requirements (Affeldt et al., 2018), Archer et al. (2021) as well as Ralle (2020) note a steadily growing heterogeneity of out-of-school labs, which results in diverse budgets, (lab) characteristics and different organizational and/or content-related approaches.

Despite international, significant improvements in gender equity within science over the last 40 years, entrenched gender differences are still reproduced (Archer et al., 2013). Mokhonko et al. (2014) speculate that the pedagogical design might be responsible for the low, positive effects of out-of-school programs. Recently published research show that out-of-school learning environments "tend to privilege dominant, western, and male forms of doing and knowing" (Archer et al., 2021, p. 170; Archer et al., 2016). Dominant approaches (see above), originally intended to broaden participation, rather maintain than reduce gendered hierarchies in informal science education (Archer et al., 2021). According to Bourdieu (1977) social reproduction emerges through the interaction of habitus (embodied, socialized dispositions) and capital (economic, social, and cultural resources) within a field (socio-historical spaces of positions and position-taking). Based on their socialization including implicit gender beliefs and gender related work, teachers, for example, still tend to have gender biases and discourage even girls who might have aspired to a professional career in STEM (Hand et al., 2017). Furthermore, gender biases influence performances including body language, facial expressions, or voice (Elsen, 2020). Regarding to less attention to girls, existent sexist language in classrooms as well as the absence of women in learning materials/books show that children are still socialized for traditional gender roles (Sadker & Sadker, 2010). Following Archer et al. (2021), who integrated a Bourdieusian (1977) approach with informal science environments' resistance to change, the "field" (e.g., power relations, values, structure, and actors) will play a major role in terms of equitable programs in out-of-school labs. Bourdieu consequently characterized "field" as a "social universe having its own laws of functioning" (Bourdieu & Johnson, 1993, p. 14). So far, research has strongly focused on the impact of lab programs on young people's motivation, identity, and interest regarding science. The influence of the out-of-school lab as "field", however, has not been investigated. Accordingly, this study focuses on the investigation of a chosen out-of-school lab ("field") regarding the promotion of girls in science.

The selected out-of-school lab for this study is in the north of Germany. It offers not only workshops for elementary school classes (grade 3 and 4, age 8-9), but also career orientation workshops for classes on secondary level (grade 8 and 9, age 14-15). In each of those workshops, four students are supervised by one staff member. Workshops, which children and teenager can attend to in their spare time, are additionally offered. Focus of the workshops is science and technology, e.g., building a plant watering system, learning to develop and to finally print an own 3D-figure or experimentally examining air and sound as natural phenomena in everyday life. While physics, chemistry and biology are taught in German primary schools as one combined subject named ‚*Sachunterricht*' (general science and social studies), they formally become separated subjects at the beginning of secondary school (grade 5 or grade 7 at the latest, age 10-13). This is opposite to other countries keeping the integrated science subject on secondary level and opposite to the chosen out-of-school lab.

According to staff, the number of girls attending workshops in their spare time is decreasing – workshops especially designed for girls (e.g., baking workshops) were only selected by boys. This suggests that the field, i.e., staff's orientations and how the workshops are run (use of material, workshop arrangements etc.) might be barriers against addressing girls.

The challenges at the selected out-of-school lab lead to our cooperation aiming at the following research questions:

1. Which factors induce that girls are (not) addressed by the out-of-school lab as "field"?
2. How can the influence of positive factors of the "field" be strengthened and that of negative factors be counteracted by a tailor-made program on site?

METHOD

To answer the research questions, an explorative case study is conducted. The study consists of four main phases following the design-based research approach (Design-Based Research Collective, 2003) to analyse practical problems and develop solutions (Figure 1). This process ensures the quality as well as the efficacy of the solution concept. In summary, the aims of the study are first to identify valuable advice on how the workshops should be designed and run to actively promote girls after the transition from primary to secondary school and second to develop a purposeful, precisely fitting program for a selected out-of-school laboratory.

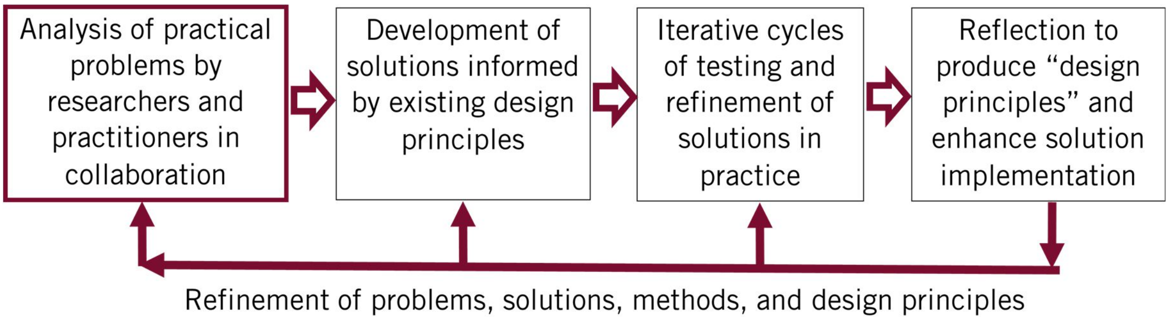

Figure 1. Design-based research approach (adapted from Reeves, 2006, p. 59).

To analyse the practical problems, episodic interviews (Flick, 2011) with staff members (n=4), who work at the selected out-of-school lab full-time, were conducted to investigate how and to what extent girls are addressed. In particular, the episodic interview is characterized by the combination of questions about subjective knowledge and narrative requests for the staff's subjective experiences during their work at the selected out-of-school lab (Flick, 2011). Thus, episodic interviews were not only conducted for precise information concerning knowledge and explicit attitudes, but also to ensure that multi-layered influences in the out-of-school lab are fully exposed during the evaluation. Examples of questions are as followed:

- How do you run your workshops?
- How do young women and men participate in your workshops?
- Based on the experience you just told me: What could be the reason for the girls' different participation during your workshop?
- Can you give me an example of how you deal with this as a teacher in that situation?

To complement the "field" with an overview of pedagogical approaches, use of materials, room arrangements etc., courses representing a cross-section of the lab's program were investigated by participatory observations (n=9) (Flick, 2018). The observations, mainly focusing on the staff's actions, are underpinning the interviews to allow additional factors to be considered. Pre-structured observation protocols and photographs were used for documenting the workshop performance, including shared material and a seating plan. The following data has been additionally collected during every observation: Workshop type, title and topic, participants' red gender, grade level, responsible staff member, further individuals, who watch the workshop activities. Staff members' verbal expressions related to addressing the as boys and girls read students during the activities (e.g., voice colour, length, and content of verbal interaction between staff member and child/teenager, type of (verbal) support) were described and documented as precisely and value free as possible.

To analyse the interview data, documentary method is applied (Nohl, 2010). This enables an in-depth insight into staff members' implicit orientations that influence the pedagogical arrangements and, consequently, whether girls are addressed in the "field". While staff members are aware of what they are saying in the interview, the documentary method allows access to a second meaning level of what is being said, as evidence of a certain attitude (e.g., a loyal attitude, a hypocritical personality) that they do not necessarily have access to. Through a "formulating interpretation", most important (sub)topics regarding their orientation about girls in STEM as research topic will be identified in order to establish, *what* the interviews are about (Nohl, 2010). The following "reflective interpretation" focuses on *how* these beliefs were elaborated and thus on the framework of orientation, in which the orientations are dealt with. Looking at the "modus operandi in which a topic is developed" leads to the focus on interviews' formal and semantic aspects in a next step (Nohl, 2010, p. 204). The observation protocols are complementarily analysed using qualitative content analysis (Kuckartz, 2019). This enables to examine the consistency of the staff's statements in the interviews, about how they support boys and girls to let them equally participate in the workshop activities, with their actual observable actions during the lab courses.

Following the design-based-research approach, the evaluation results gained in phase 1 will be used to develop a theory-based concept to solve the problems currently prevailing at the out-of-school lab (phase 2). The further phases will be successively developed based on the results of the previous phases.

RESULTS

The elaborate documentary analysis is pending. Only preliminary results can be presented. An initial review of the interview material suggests that all full-time staff members, according to their own statements, intent no (conscious) distinction between girls and boys during their workshops. Gender differences in workshop activities are not attributed to the biological sex per se, but rather to stereotypes, role expectations, and "how the students grew up". All interviewed staff members reported about their deliberate use of measures to enable girls and boys to equally participate in their activities. Moreover, information about gender and science education as the interviewers' research fields as well as rough (and well-considered) knowledge of the divergent development of girls' and boys' interest in science, the first author shared in the first meeting, must have influenced the interviewees' choice of words. Three interviewees independently adopted the phrase "historically conditioned" during the meeting, to underpin their attitudes related to the existing gender segregation in STEM. In contrast to her colleagues, one staff member did not take part in the first ever meeting and did not use corresponding formulations. Concurrent with her different choice of words this staff member additionally told the interviewer about stereotypical attitudes of the management about girls in STEM and their existing effect (especially) on the female team members. Consequently, it seems reasonable to both analyse the conducted interviews in-depth and do further interviews with the management (n=2) with an adapted interview manual. Whether and to what extent more interviews are necessary with other staff members, will be determined by following analysis steps through the documentary method for a deeper elaboration of the staff's implicit orientations.

Furthermore, preliminary impressions already exposed due to non-standardised, participatory observations. Indications of differences in addressing girls and boys through the shared material, the use of space, or the staff's body language could not be determined at first glance. In contrast, notable differences on verbal level could be exposed between the addressing of girls and of boys by one staff member, who was the only one with a pedagogical background by studying educational science. For instance, three girls and one boy (grade 8) attended a career orientation workshop to build a plant watering system. In pairs, the teenagers had a laptop to electronically report the solutions for the associated tasks on a learning platform. Both teams sat opposite from each other on the group table. When the girl, who was in a team with the boy, asked the staff member, how she could log in the learning platform, he enumerated the buttons to press on the keyboard and, as if giving step-by-step instructions, told her which words she needed to type in one by one. The boy also seemed to struggle with using the learning platform, as he asked questions about how to select and upload images. In contrast to helping the girl, the staff member first looked at the laptop screen, waited and told him which buttons would be helpful instead. Through observation, it can be additionally surmised that the supervisor mainly responded to the teenagers' actions rather than actively engaging them in the activities. By exclusively asking questions for a deeper understanding of the tasks and working with the platform, mainly the boy interacted with the staff member. The girl, who was grouped with the boy, repeatedly ran with both of her hands through her hair in front of her face or twisted several wires of the electronic circuit between her fingers while sitting between the supervisor and her team partner. Without having analysed the scene in detail so far, this observed behaviour could indicate that she was not addressed by the supervisor by then. In comparison, the other two girls took on the task without asking questions. Two to three times the supervisor approached to them and inquired how the task was going. It was recognizable that the girls spent a large part of the workshop watching the other group. When the teenagers were already gone, the girls' behaviour was described by the staff member as restrained, not interested, and/or unmotivated. Indications of no interest, motivation, or restraint on side of the girls were not observable at first sight. It is also interesting to note at this point that the staff member seems to measure interest in a STEM-topic by the number of times the student participated in the workshop by asking/answering questions. In this context, the as "interested" characterized boy's inquiries were not content-related but administrative regarding how to use the learning platform. Whether and to what extent these initial assumptions can be confirmed must be examined by the qualitative content analysis.

Accordingly, following analyses will focus on the verbal interaction between the full-time staff and the children to further deepen the comparison of their statements about their addressing measures with their actual actions by the qualitative content analysis.

DISCUSSION

A significant number of established out-of-school science environments all over Europe shows that promoting girls and boys in science is an international matter (Hausamann, 2012). The pedagogical approaches of extracurricular concepts in out-of-school learning environments differ sharply, even though they pursue the common, major goal of not only promoting children's and young people's interest and openness towards science and technology, but also enabling inquiry-based learning in authentic learning environments (Ralle, 2020). Because of these differences, it is quite impossible to evaluate and compare their effectiveness by means of empirical studies. Accordingly, an exemplary in-depth analysis of a chosen out-of-school lab, where girls decreasingly attend workshops in their spare time, is conducted to further analyse influencing aspects, for instance the usage of materials or room arrangements, in terms of addressing girls in STEM. Regarding primary impressions without deeper analysis steps, staff members' (verbal) actions towards girls in STEM can be identified as one influencing factor of the chosen out-of-school lab. It seems important for the staff to attend a pedagogical workshop about supervising children in a learning environment and being aware of their influence on children in general. Based on the girls' observed behaviour, the staff member did not seem to address her by his verbal expressions. Accordingly, following analysis steps will focus on further differentiating the influence of staff members' verbal expressions. Consequently, preliminary results not only confirm Arthur et al.'s (2021) approach about the individual influence of out-of-school labs as "field". By an exemplary, in-depth analysis of the staff members, the used material and room arrangements as influencing factors of a chosen lab, the results will also widen the current research about extracurricular learning environments, which particularly examined the effectiveness of implemented programs on site so far.

Once a thorough analysis of the situation on site can be made, specific problems will be chosen to be considered and solved in the developed program. For instance, the program could include a new pedagogical design for the chosen out-of-school science lab, a workshop for the management and staff and other valuable advice on how programs could be designed and run to actively promote girls in science.

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REFERENCES

Affeldt, F., Siol, A., Markic, S. & Eilks, I. (2018). Neue Ansätze zur Differenzierung im Schülerlabor [New Approaches for Differentiation in an out-of-school lab]. *CHEMKOM*, *25*(7), 255-262. https://doi.org/10.1002/ckon.201700502

Archer, L., Godec, S., Calabrese, Barton A., Dawson, E., Mau, A. & Patel U. (2021). Changing the field: A Bourdieusian analysis of educational practices that support equitable outcomes among minoritized youth on two informal science learning programmes. *Science Education*, *105,* 166-203. https://doi.org/10.1002/sce.21602

Archer, L., Dawson, E., Seakins, A., & Wong, B. (2016). Disorientating, fun or meaningful? Disadvantaged families' experiences of a science museum visit. *Cultural Studies of Science Education*, 11, 917-939. https://doi.org/10.1007/s11422-015-9667-7

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': primary school girls' and parents' constructions of science aspirations. *Pedagogy, Culture & Society*, *21,* 171-194. https://doi.org/10.1080/14681366.2012.748676

American Association of University Women (AAUW) (2010). *AAUW annual report*. AAUW.

Bourdieu, P. (1977). Cultural reproduction and social reproduction. In J. Karabel & A. H. Halsey (Eds.), *Power and Ideology in Education* (pp. 487-511). University Press.

Calabrese Barton, A., & Tan, E. (2018). A longitudinal study of equity-oriented STEM-rich making among youth from historically marginalized communities. *American Education Research Journal*, *55*(4), 761–800. https://doi.org/10.3102/0002831218758668

Dawson, E. (2019). *Equity, exclusion and everyday science learning: The experiences of minoritised groups*. Routledge.

Dawson, E. (2014). "Not Designed for Us": How Science Museums and Science Centers Socially Exclude Low-Income. Minority Ethnic Groups. *Science Education*, *98*(6), 981-1008. https://doi.org/10.1002/sce.21133

Dasgupta, N. & Stout, J. G. (2014). Girls and Women in Science, Technology, Engineering, and Mathematics: STEMing the Tide and Broadening Participation in STEM Careers. Policy *Insights from the Behavioral and Brain Sciences*, *1*(1), 21-29. https://doi.org/10.1177/2372732214549471

Design-Based Research Collective (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, *32,* 5-8. https://doi.org/10.3102/0013189X032001005

Elsen, H. (2020). *Gender – Sprache – Stereotype* [Gender – Language – Stereotypes]. utb.

Euler, M., Schüttler, T. & Hausamann, D. (2015). Schülerlabore: Lernen durch Forschen und Entwickeln [Out-of-school labs: Learning through research and development]. In E. Kircher, R. Girwidz & P. Häußler (Eds.), *Physikdidaktik* (pp. 759-782). Springer.

Federal Employment Agency statistics (2019). *Berichte: Blickpunkt Arbeitsmarkt – MINT-Berufe* [Reports: Focus on the labour market - STEM professions]. Federal Employment Agency. https://statistik.arbeitsagentur.de/DE/Statischer-Content/Statistiken/Themen-im-Fokus/Berufe/Generische-Publikationen/Broschuere-MINT.pdf?__blob=publicationFile [12.01.2022].

Flick, U. (2018). *An Introduction to Qualitative Research (6th ed.)*. SAGE Publications.

Flick, U. (2011). Das episodische Interview [The episodic interview]. In G. Oelerich & H.-U. Otto (Eds.), *Empirische Forschung und Soziale Arbeit. Ein Studienbuch* (pp. 273-280.). Springer Fachmedien.

Flick, U. (2000). Qualitative inquiries into social representations of health. *Journal of Health Psychology*, *5*(3), 315-324. https://doi.org/10.1177/135910530000500303

Haffner, Y. & Loge, L. (2019). Frauen in Technik und Naturwissenschaft: ein Überblick [Women in Technology and Natural Science: an overview]. In Y. Haffner & L. Loge (Eds.), *Frauen in Technik und Naturwissenschaft: Eine Frage der Passung. Aktuelle Erkenntnisse und Einblicke in Orientierungsprojekte* (pp. 7-20). Barbara Budrich.

Hand, S., Rice, L. & Greenlee, E. (2017). Exploring teachers' and students' gender role bias and students' confidence in STEM fields. *Social Psychology of Education*, *20*, 929-945. https://doi.org/10.1007/s11218-017-9408-8

Hausamann, D. (2012). Extracurricular Science Labs for STEM Talent Support. *Roeper Review*, *34,* 170-182. https://doi.org/10.1080/02783193.2012.686424

Kuckartz U. (2019) Qualitative Text Analysis: A Systematic Approach. In G. Kaiser & N. Presmeg (Eds.), *Compendium for Early Career Researchers in Mathematics Education. ICME-13 Monographs* (pp. 181-197). Springer, Cham. https://doi.org/10.1007/978-3-030-15636-7_8

Master, A. (2021). Gender Stereotypes Influence Children's STEM Motivation. *Child Development Perspectives*, *15*(3), 203-210. https://doi.org/10.1111/cdep.12424.

Master, A. & Meltzoff, A. N. (2020). Cultural Stereotypes and Sense of Belonging Contribute to Gender Gaps in STEM. *International Journal of Gender, Science and Technology*, *12*(1), 152-198.

Mc Nally, S. (2020). Gender Differences in Tertiary Education: What explains STEM Participation? *EENEE Analytical Report No. 41. Prepared for the European Commission*. https://doi.org/10.2766/421080

Miller, D. I., Nolla, K. M., Eagly, A. H., & Uttal, D. H. (2018). The Development of Children's Gender-Science Stereotypes: A Meta-analysis of 5 Decades of U.S. Draw-A-Scientist Studies. *Child Development*, *89,* 1943-1955. https://doi.org/10.1111/cdev.13039

Mokhonko, S., Nickolaus, R., & Windaus, A. (2014). Förderung von Mädchen in Naturwissenschaften: Schülerlabore und ihre Effekte [Promoting girls in science: out-of-school labs and their effects]. *Zeitschrift für Didaktik der Naturwissenschaften*, *20,* 143-159. https://doi.org/10.1007/s40573-014-0016-2

Nohl, A.-M. (2010). Narrative Interview and Documentary Interpretation. In R. Bohnsack, N. Pfaff & W. Weller (Eds.), *Qualitative analysis and documentary method in international educational research* (pp. 195-217). Barbara Budrich. https://nbn-resolving.org/urn:nbn:de:0168-ssoar-317517

OECD (2019). *Why don't more girls choose to pursue a science career? PISA in Focus #93*. https://doi.org/10.1787/02bd2b68-en

Ralle, B. (2020): Empirische Forschung in Schülerlaboren - eine anspruchsvolle Aufgabe [Empirical research in out-of-school science labs – a challenging task]. In K. Sommer, J. Wirth & M. Vanderbeke (Eds.), *Handbuch Forschen im Schülerlabor. Theoretische Grundlagen, empirische Forschungsmethoden und aktuelle Anwendungsgebiete* (pp.13–17). Waxmann.

Reeves, T. (2006). Design research from a technology perspective. In J. Van den Akker, K. Gravemeijer, S. McKenney & N. Nieveen (Eds.), *Educational Design Research* (pp. 52-66.). Routledge https://doi.org/10.4324/9780203088364

Sadker, M. & Sadker, D. (2010). *Failing at fairness: How America's schools cheat girls*. Simon and Schuster.

Schipolowski, S., Wittig, J., Mahler, N., Stanat, P. (2019). Geschlechtsbezogene Disparitäten [Gender Disparities]. In P. Stanat, S. Schipolowski, N. Mahler, S. Weirich & S. Henschel (Eds.), *IQB-Bildungstrend 2018. Mathematische und naturwissenschaftliche Kompetenzen am Ende der Sekundarstufe I im zweiten Ländervergleich* (pp. 237-264). Waxmann.

Schleicher, A. (2019). *PISA 2018. Insights and Interpretations*. OECD. https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf [12.01.20222]

Stocklmayer, S., Rennie, L. J. & Gilbert, J. K. (2010). The roles of the formal and informal sectors in the provision of effective science education. *Studies in Science Education*, *46*(1), 1-44. https://doi.org/10.1080/03057260903562284

Stoet, G. & Geary, D. C. (2020). Corrigendum: The Gender-Equality Paradox in Science, Technology, Engineering and Mathematics. *Psychological Science*, *31*(1), 110-111. https://doi.org/10.1177/0956797619892892

Stoet, G. & Geary, D. C. (2018). The Gender-Equality Paradox in Science, Technology, Engineering and Mathematics. *Psychological Science*, *29*(4), 581-593. https://doi.org10.1177/0956797617741719

Wieselmann, J. R., Roehrig, G. H., & Kim, J. N. (2020). Who succeeds in STEM? Elementary girls' attitudes and beliefs about self and STEM. *School Science and Mathematics*, *120,* 297-308. https://doi.org/10.1111/ssm.12407

A CARD GAME FOR FOSTERING SUPPORT BETWEEN FEMALE STUDENTS AND PARENTS IN SCIENCE VOCATIONAL ORIENTATION

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Girls and young women of non-dominant ethnicity are less likely to aspire to a career in science. This results in a gender misrepresentation that needs to be addressed in vocational orientation. Research has shown that parents play a major role in vocational orientation in science. Further, talking about science with family and friends contributes to science career plans regardless of parental education. In the research project "DiSenSu - DiversitySensitive Support", this knowledge was used to develop a card game for vocational orientation in science. The game intends to stimulate talking about vocational orientation in the field of science between young women and their parents. It can be used on various occasions outside of school, with or without parents. The goal is to encourage young women with a migration background and their relatives to reflect on science careers. The present study analyses how the card game fosters support between daughters and parents through initiating conversations between the players about science careers, their experiences with science, and their feelings towards the subject. The game was evaluated using quantitative data obtained through game statistics and a questionnaire with Likert items. In addition, qualitative data were collected using recordings of three conversations between daughters and parents while playing the game combined with researchers' observations. The results show that the card game has the potential to initiate conversations about vocational orientation and thereby foster support in vocational orientation in science.

Keywords: Vocational Education, Parental Involvement in Learning, Gender Issues

INTRODUCTION

Career orientation programs are part of everyday school life in secondary schools. In this context, the highest authorities in German education policy, the Ministers of Education, agreed on a resolution that requires all teachers and other professionals involved in school to actively engage in career orientation (Kultusministerkonferenz, 2017). Moreover, the Ministers stated that teachers and other professionals involved have to take into account the identity formation processes of young people because the goal is to allow students to choose a career regardless of stereotypes (Kultusministerkonferenz, 2017). This is an important yet challenging goal for science teachers who are mainly trained for their subjects and often do not learn how to do vocational orientation appropriately (Küsel, Hönig, Rüschenpöhler, & Markic, 2021).

A major challenge in vocational orientation in the field of science and technology is the phenomenon that career aspirations are strongly influenced by gender, class, and race (Archer et al., 2013; Archer, Dewitt, & Osborne, 2015; Archer, DeWitt, & Willis, 2014; Carlone, Webb, Archer, & Taylor, 2015). Women tend to have lower science career aspirations than men (Archer et al., 2010). This translates into a gender misrepresentation in science professions in which women are often underrepresented, especially in Western countries (OECD, 2009). One reason for this could be the very limited range of accepted female science identities (Archer et al., 2013). Similar difficulties are documented for people of the working class and non-dominant ethnicity (Archer, Dewitt, et al., 2015; Carlone et al., 2015).

In the project "Diversity Sensitive Support: vocational orientation in STEM for female adolescents with a migration background in cooperation with parents (DiSenSu)" (Technical University of Darmstadt and Ludwigsburg University of Education; www.disensu.de), career orientation interventions were conducted targeting young women with migration background. The goal was to allow for a vocational orientation for science professions, considering the influence of existing stereotypes in this field on young women.

Certain aspects of the interventions are based on the concept of Science Capital (Archer, Dawson, DeWitt, Seakins, & Wong, 2015), such as the interviewing strategies (Rüschenpöhler, Küsel, Hönig, & Markic, 2020) and the collaboration with parents. Science Capital describes the influences of gender, class, and race on science identity formation as well as on chemistry identity formation (Rüschenpöhler & Markic, 2020). Science capital can be understood as the resources that have value in the field of science. The concept, thus, shifts the attention to the resources that students have. Further, it can guide how to support students in their acquisition of these resources (Rüschenpöhler & Markic, 2020).

Parents and other relatives play a central role in young people's career choices (Esch & Grosche, 2011). This can be problematic because knowledge about science professions is scarce in socially disadvantaged families (Archer, Dewitt, et al., 2015). However, parents can also provide science capital and thus strongly influence their children's career aspirations toward science. Some parents have science qualifications or a science-related job. But even without this science capital, parents can provide resources for their children: talking about science with family and friends can lead to an emotional attachment to science (Rüschenpöhler & Markic, 2020) and thus potentially influence career choices toward science.

In the project DiSenSu, these insights were used to develop an intervention to support young women with migration background in their vocational orientation in science: a card game was designed to initiate conversations between young women and their parents or relatives about science careers. It is based on the science capital approach and was developed, tested, and evaluated.

This article presents the playing cards, the rules of the game, and how this game can be used in practice. Further, the results from the evaluation show how the players evaluate the card game and how conversations about science professions can be initiated. The complete game in German language can be found in Hönig, Küsel, and Rüschenpöhler (2021).

THE GAME

The card game (fig. 1) seeks to foster the Science Capital of the players by initiating conversations about their attitudes and feelings towards science careers. The card game is, therefore, based on certain aspects of Science Capital (Archer, Dawson, et al., 2015), stimulating mutual support between the players in career orientation in science.

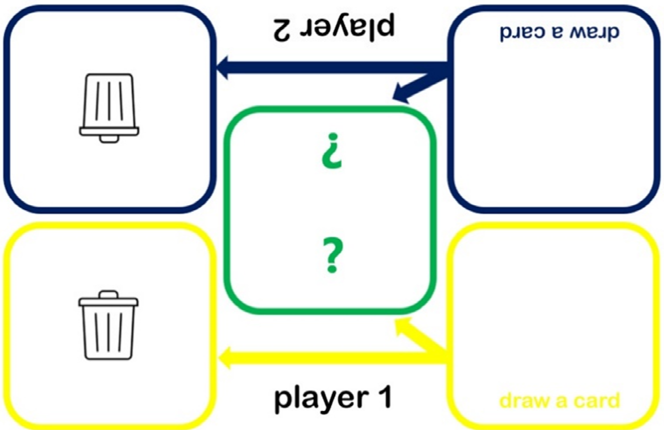

Figure 1. Board of the game for game variant A (a young woman plays with a parent).

In particular, the game is designed to stimulate

- conversations about the players' emotions regarding careers in science,
- conversations about knowledge regarding professions in science, and
- joint action for the career orientation of the young women.

Two variants of the game were developed. Variant (A) was developed for games between a young woman and a parent or some other relative. This variant of game can, therefore, be used in a variety of contexts where parents are present with their daughters, e.g., at career orientation events, at school parties, at clubs, or it can be played individually at home. Variant (B) was developed for games between two young women e.g., during career orientation weeks at school.

The conversations during the game are guided by four types of playing cards:

- *Type 1: Reflection on science professions*. Some cards of this type provide information about a specific science job, combined with a question. Other cards in this category are designed to initiate the players to share their knowledge about and experiences with science jobs.
- *Type 2: Obtaining feedback*. These cards stimulate the players to give each other feedback, e.g., on the person's strengths or if they could imagine the other person working in science.
- *Type 3: Reflecting on the process of career orientation*. Cards of this type contain questions about the process of career orientation in science or on the process in general. Some cards focus on the thoughts and feelings of the players.
- *Type 4: "Imagine…" – adopting the perspective of a person working in science*. These cards stimulate a change of perspective. The players are asked to imagine being in a certain situation or working in a science-related job. Some cards contain questions that stimulate a reflection on gender stereotypes.

Examples of the cards can be found in table 1. Before starting to play, each player mixes the cards of all four types for his/her stack. Then, every player draws a set of cards from his/her stack, and the players play them alternately: player 1 chooses a playing card and presents it to player 2, who has to answer the question. During the turn, player 1 also dismisses a card that he/she does not want to play. Then the game continues with the turn of player 2. The game ends either (i) when all cards have been played/dismissed (ii) when the time is up (this can be defined by the organiser) or (iii) when the players do not want to continue. No one can win or lose the game.

Table 38. Examples for the four categories of cards (Hönig et al., 2021).

(1) **Imagine working in this job.** **What would that be like for you?**  © *Portra/DigitalVision* **Angelina, lab technician specialised in lacquers** I develop new lacquers and monitor their quality. I work both in the lab and on the production site where we test the lacquers. **Tasks.** Developing lacquers, testing, and optimising the formulae, monitoring their quality.	**(2)** **In which field can you imagine me working later?**  © colourbox.com
(3) **What fears do you have regarding your career choice?**  © *colourbox.com*	**(4)** **Imagine you work in a job that you don't like at all. What does this job look like? What don't you like about this job?**  © *colourbox.com*

RESEARCH

For evaluating the game, two aspects were investigated:

(i) Which card types help young women and their relatives to engage in meaningful conversations about career orientation in science?

(ii) How do the players support each other during the game and thereby promote Science Capital? This question was also investigated regarding the specific playing cards which tend to initiate mutual support.

METHODS

Due to the COVID-19 pandemic, an online version of variant (A) of the card game was programmed, which allowed parents and daughters to play the game at home ($N_{parents} = N_{daughters} = 13$). Variant (B) for two girls was piloted as a career orientation intervention in a class of ninth graders (N = 27, mean age: 14) in a secondary school with a high proportion of students with a migration background ($N_{migration\ background}$ = 17; 63 %; $N_{girls\ with\ a\ migration\ background}$ = 9). Since variant (A) for a young woman with a parent and variant (B) for two girls have the same focus and are in many aspects very similar, it is assumed that the research on both variants provides evidence for both research questions. The collected data of the two variants will be analysed separately but discussed and interpreted jointly.

A mixed-methods study with triangulation was conducted using quantitative and qualitative data:

(a) A *questionnaire with Likert items* was used to collect quantitative data from the players of both variants after playing. In the first part of the questionnaire, the players were asked to give feedback on the individual cards and the four card types. In the second part of the questionnaire, the players were asked how far they had shared emotions and knowledge about the process of vocational orientation and professions in science, in the sense of Science Capital. Further, the players were asked if the players could imagine continuing to work together with their game partner in career orientation.

(b) *Descriptive statistics of the gameplay* were recorded. These data were available because it was played online. It was measured which cards were played or dismissed by the players. This served as another source of evidence for the quality of the cards, complementing the self-report data from the questionnaire (a).

(c) *Five conversations were recorded as audio files* ($N_{students}$ = 10). This was possible only for variant (B) for two girls which was played face-to-face in school. The audio data were transcribed and a qualitative analysis was conducted according to Mayring (2014). In the analysis, we focused on the sharing of emotions and knowledge, and which playing cards stimulated the conversations. Further, we tried to determine if the players planned joint action in vocational orientation.

RESULTS

(i) *The four types of playing cards*. The cards were rated differently by the parents and the young women. The analysis of the parents' cards shows that they rated the cards of type 3 (Reflecting on the process of career orientation) as particularly fruitful for the conversation with their child (51% of the played cards; conversation stimulus rating: 2.3 on a scale of 1-3). Card type 3 contained questions such as "What is most important to you regarding your future career?", "Do you talk to your friends about what you want to do when you grow up?", or "Why do you think (or do not think) a science career would suit you?". For the daughters, all card types seemed to be similarly interesting, but getting feedback on how their parents perceived them seemed to be most relevant. The cards of type 2 (Obtaining feedback) were perceived as particularly conducive (36% of cards played, conversation stimulus rating: 2.67). Examples of very popular questions of this card type are: "What type of career can you imagine for me in the future?", "What field do you imagine me working in later?", or "What science careers that you know of could suit me?". In variant (B) for two girls, the results show that the most popular card types among the adolescents were type 3 (Reflecting on the process of career orientation) and type 4 ("Imagine…" – adopting the perspective of a person working in science). Regarding these card types, the conversations were particularly lively in the audio recordings, and 25% of the students expressed in the questionnaires that they would like to have more cards of these types in the game. The other card types (1 and 2) were less popular so that 32% of the students stated they would prefer fewer cards of these types in the game.

(ii) *How the players support each other during the game*. The parents experienced more sharing of emotions ($M_{parents}$ = 3.09; scale of 1-4) than of knowledge ($M_{parents}$ = 2.89) in the conversation. In contrast, the daughters experienced little sharing of emotions ($M_{daughters}$ = 2.21) and more sharing of knowledge ($M_{daughters}$ = 2.72). The potential of the game to stimulate the players to joint action in vocational orientation seemed to be rather limited; parents and daughters could imagine engaging in joint action only little ($M_{parents}$= 2.58; $M_{daughters}$ = 1.95). In variant (B) for two young women, a similar picture emerged for sharing knowledge ($M_{students}$ = 2.32) and the stimulation of joint action ($M_{students}$ = 1.91), with the exception that they experienced a strong sharing of emotions ($M_{students}$ = 2.92).

The descriptive statistics of the online gameplay between parents and daughters indicated that many cards primarily stimulated emotional and content sharing. In contrast, the cards encouraged the players only a little to engage in joint action for vocational orientation. The parents' playing card that particularly prompted the players to share emotions was "What do you wish from us, your family, regarding your future career? How important is our opinion about your career choices to you?". 80% of parents stated that this card fostered emotional support in the conversation. The daughters' playing card which seemed to stimulate sharing of content was the question, "Imagine you were at my age again and you would have to decide on a career path. Would you be interested in a science career? Why (not)?". 36% of the students confirmed this after having played this card. Finally, some cards stimulated conversations in all three aspects, e.g., "What field do you see me working in later?" When this card was played, it promoted either emotional (50%) or content-related sharing (17%) or a shared action (33%).

These results are consistent with the qualitative analysis of the conversations between the players in variant (B) for two girls. The players expressed genuine interest in each other and thereby provided emotional support. In many conversations, while playing, it became apparent that the players' emotional support was not science-specific but referred to career choices in general. For example, they wished the other person a fulfilled future, that his/her profession shall be fun and fulfil his/her wishes. Some playing cards stimulated a sharing of knowledge and attitudes concerning specific scientific professions. However, in variant (B), this exchange was rather superficial and based mainly on the information on the playing cards. They talked very generally about the professions they did (not) wish for and justified this with a corresponding activity mentioned on the card. Rarely did they speak about their own experience. No joint action (such as doing more research together or visiting a career fair) was planned in the game talk.

DISCUSSION

The results show that the card game can initiate conversations about career orientation in science without third parties being present (career counsellor, teachers). The game provided parents and other relatives the opportunity to take an active role in the career orientation of young women. Social Science Capital (Archer, Dawson, et al., 2015) could be promoted. The game encourages young women with migration background to talk about and reflect on professions in the field of science. In particular, it creates a space in which the players can support the young women emotionally by expressing their feelings regarding science. In some cases, we also observed an exchange of knowledge and other content related to professions in general and the science professions presented on the playing cards. Thereby, the young people can develop new resources in the sense of Science Capital. The card types 3 *(Reflecting on the process of career orientation)* and 4 (*"Imagine…" – adopting the perspective of a person working in science*) seemed to be most effective to initiate conversations about career orientation in science between young women and their relatives (variant A) or two young women (variant B). Both variants of the game can be found in Hönig et al. (2021).

The evaluation also showed that, before playing the game, it would be important to clarify what science is and what professions might be science-related. If this is not clear, it is difficult to use the game in a way that is beneficial for all participants. When analysing the qualitative data, we noticed that many students lacked this knowledge, which made it difficult for them to engage in meaningful conversations. Moreover, some showed a low science self-concept and some stereotypes ("you have to be smart for that") or misconceptions ("being a doctor is not a scientific profession") and could not use the game fruitfully.

Therefore, it would be beneficial to discuss in class what science is and what professions are science-related, before playing the game. Alternatively, the game could be used at the end of the school career of students who have already dealt with these issues more intensely in school and in their free time. At this stage, more knowledge could be available among the young people to initiate good conversations while playing the game. However, this runs the risk that students have already made their choices.

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REFERENCES

Archer, L., Dawson, E., DeWitt, J., Seakins, A., & Wong, B. (2015). "Science capital": A conceptual, methodological, and empirical argument for extending bourdieusian notions of capital beyond the arts. *Journal of Research in Science Teaching*, *52*(7), 922–948. http://doi.wiley.com/10.1002/tea.21227

Archer, L., Dewitt, J., & Osborne, J. (2015). Is science for us? Black students' and parents' views of science and science careers. *Science Education*, *99*(2), 199–237. http://doi.wiley.com/10.1002/sce.21146

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2010). "Doing" science versus "being" a scientist: Examining 10/11-year-old schoolchildren's constructions of science through the lens of identity. *Science Education*, *94*(4), 617–639. http://doi.wiley.com/10.1002/sce.20399

Archer, L., DeWitt, J., Osborne, J., Dillon, J., Willis, B., & Wong, B. (2013). 'Not girly, not sexy, not glamorous': Primary school girls' and parents' constructions of science aspirations. *Pedagogy,* *Culture & Society*, *21*(1), 171–194. http://www.tandfonline.com/doi/abs/10.1080/14681366.2012.748676

Archer, L., DeWitt, J., & Willis, B. (2014). Adolescent boys' science aspirations: Masculinity, capital, and power. *Journal of Research in Science Teaching*, *51*(1), 1–30. http://doi.wiley.com/10.1002/tea.21122

Carlone, H. B., Webb, A. W., Archer, L., & Taylor, M. (2015). What kind of boy does science? A critical perspective on the science trajectories of four scientifically talented boys. *Science Education*, *99*(3), 438–464. http://doi.wiley.com/10.1002/sce.21155

Esch, M., & Grosche, J. (2011). Fiktionale Fernsehprogramme im Berufsfindungsprozess. Ausgewählte Ergebnisse einer bundesweiten Befragung von Jugendlichen. In Bundesministerium für Bildung und Forschung (Ed.), *MINT und Chancengleichheit in fiktionalen Fernsehformaten* (pp. 16–31). Bonn/Berlin: Bundesministerium für Bildung und Forschung.

Hönig, M., Küsel, J., & Rüschenpöhler, L. (2021). Berufsorientierung im naturwissenschaftlichen Bereich – Let's play! Are we scientists? *RAABits Realschule Chemie*.

Kultusministerkonferenz. (2017). *Empfehlung zur Beruflichen Orientierung an Schulen (Beschluss der Kultusministerkonferenz vom 07.12.2017)*. Berlin: Sekretariat der Ständigen Konferenz der Kultusminister der Länder in der Bundesrepublik Deutschland. https://www.kmk.org/fileadmin/Dateien/veroeffentlichungen_beschluesse/2017/2017_12_07-Empfehlung-Berufliche-Orientierung-an-Schulen.pdf

Küsel, J., Hönig, M., Rüschenpöhler, L., & Markic, S. (2021). Berufsorientierung zu chemischen Berufen: Ein vernachlässigter Bereich der Bildung von Lehrer:innen. *CHEMKON*. https://doi.org/10.1002/ckon.202100029

Mayring, P. (2014). *Qualitative content analysis: Theoretical foundation, basic procedures and software solution*. Klagenfurt.

OECD. (2009). Chart A4.6 Tertiary graduates in science-related fields among 25-34 year-olds in employment, by gender (2009). *Education at a Glance 2011*. http://statlinks.oecdcode.org/962011041P1G020.XLS

Rüschenpöhler, L., Küsel, J., Hönig, M., & Markic, S. (2020). Gesprächsführung in der Berufsorientierung: Strategien zur Förderung naturwissenschaftlicher Identitäten nach dem Science-Capital-Ansatz. *CHEMKON*. https://onlinelibrary.wiley.com/doi/10.1002/ckon.202000056

Rüschenpöhler, L., & Markic, S. (2020). Secondary school students' acquisition of science capital in the field of chemistry. *Chemistry Education Research and Practice*, *21*(1), 220–236. https://doi.org/10.1039/C9RP00127A

INVESTIGATION OF THE EFFECT OF UNDERGRADUATE STUDENTS' HIGH SCHOOL PHYSICS IDENTITIES ON THEIR CAREER SELECTIONS

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In this study, the aim was to form a casual path model with a mediator variable for career choice, which involved the variables of career outcomes, high school physics experiences, high school physics identities as the multipredictors of the career choice of a group of undergraduate students. The direct, indirect and total effects of career outcomes, high school physics experiences, high school physics identities on career choice in the pertinent model were examined in the research which was set up as a predictive correlational research model. The study group of the research was determined by stratified objective sampling method. The study group consists of a total of 693 first year students of which 77.8% (n = 539) female and 22.2% (n = 154) male in a state university. The students continue their education in physics, mathematics, chemistry, biology, physics teacher, mathematics teacher, chemistry teacher, biology teacher and science teacher. Demographic Information Questionnaire, High School Career Output Expectations and Physics Experiments Questionnaire and Physics Identity Scale developed by the researcher were used in obtaining research data. Data were tested via path analysis. This research has achieved two conclusions. The first result is about whether the physics identity scores of students according to sex differ or not. Unlike other researches, in this study, girls had higher scores in physics identity and in all sub-identities than boys. This result, which is different from other researches, may be a new and different experience for researchers and teachers. The second conclusion is that physics identity is a strong predictor of students' career choice in areas related to basic sciences. This conclusion emphasizes the perceptions of students about physics and the importance of those perceptions on career preferences. These findings provide a basis for future research as well as directing educators and researchers to understand how they could affect students' physics identity

Keywords: Pre-service teacher education, Gender issues, Quantitative methods

INTRODUCTION

The development of physics science as a field lags behind the growth of other science, technology, engineering and mathematics (STEM) fields (Irving & Sayre, 2015). Therefore, the number of students who choose to be a physicist is also less (Woolnough, 1994; Seymour & Hewitt, 1997; Hazari & Potvin, 2005; Oon & Subramaniam, 2011). It is reported that the number of university students who choose to work in the fields of physics, engineering and mathematics has decreased in many countries in Europe (Osborne & Dillon, 2008). However, although students who are successful in physics are more likely to turn to STEM fields (Tyson et al., 2007), it is seen that the problem of keeping students in the field of physics negatively affects the rate of development of this field (Irving & Sayre, 2015). In this manner, professional identity development is an important element that can affect students' academic and future career development.

Identity, which researchers especially emphasize and perceives as an analytical tool in order to understand the school and society, is an element that has many different meanings. The concept of identity has a quality that takes its roots from Lev Vygotsky and Erik Erikson and is associated with psychological and sociological processes. Identity is defined as the participation of individuals in the world and how this participation is interpreted by others (Erikson, 1980; Gee, 2000). It is suggested that the effect of the interaction of individuals in the social environment in the development and transformation of the concept of identity has a function in terms of raising the awareness of individuals themselves. In this sense, it supports the argument that individuals' identity is shaped as a result of sociocultural influences in the fields of education and training, career choice, and may tend to make choices accordingly (Irving & Sayre, 2015).

Expanding the identity development approach developed by Carlone & Johnson (2007), Hazari et al. (2010) listed the processes that affect students' physics identity development as follows: • Interest was defined as the personal desires of individuals to understand and learn more about the field of physics and the voluntary activities they exhibit in this field. • Competence is defined as people's beliefs about their ability to understand the contents of physics. • Performance is defined as the beliefs of individuals in their ability to perform tasks related to certain physics issues. • Recognition is characterized as recognition of people as physicists by others.

Within the framework of these concepts, Hazari et al. (2010) consider the concepts of interest and recognition to be the main factors in students' self-definition as individuals from the field of physics. In addition, they argued that the concept of physics identity is "quasitrait" and is an element that can change over time with different learning experiences.

Gillibrand et al. (1999) examined the participation of female students in physics lessons in single and mixed schools, and in the study, they conducted in England, female students were discussed in terms of self-confidence and perception of success. In the study, it was stated that female students were less prominent than male students in physics lessons, and this gender imbalance was higher in upper grades. Haussler and Hoffman (2000) conducted an intervention study in Germany in order to increase the interest and success level of female students in physics lessons and to ensure the formation of self-concept. It has been mentioned that it is important to create an educational environment where changes are made in the curriculum depending on the students and their experiences. In addition, it is thought that teachers should be competent in supporting female students in terms of developing self-concept and physics identity, and the school should have different conditions in order for female students to have the opportunity to develop physics identity. In the intervention study developed in the context of these goals, the sixty-hour physics course was restructured, and then the students were measured about the achievements in the course. According to the results obtained, it was determined that the lessons that were restructured considering the orientation, experience and interests of female students gave successful results. In another study, which deals with the effects of high school physics courses and emotional factors on the development of physics identity, it is discussed whether the gender difference in terms of these factors causes a significant difference among the students who take the physics course, which is given as an introductory course in the first year of universities. Hazari et al., in this study conducted in 2007, applied questionnaires to 1973 university students who took physics courses at the beginner level. Variables related to demographic and previous learning of students were also examined (Hazari et al, 2007). In line with the results obtained, it was seen that the physics course and emotional experiences taken in the high school period had different results in terms of predicting the performance of female and male students. It was determined that the variables that were predicted at different levels in girls and boys were long written problems, cumulative exams, father's encouragement of his child and family's thought that it is good to have a career in science. On the other hand, the factor that has been found to have a similar effect for female and male students is that high school mathematics education, which is one of the previous learning, affects the physics performance at the university (Hazari et al, 2007).

In summary, students do not feel that they belong to basic sciences, they are not interested and they do not see themselves as talented. For this reason, what needs to be done is to ensure that students develop an identity for basic sciences starting from high school and even primary education. In this context, this study will make an important contribution to increase the interest in basic sciences, as it will be determined how the students' high school physics identities develop and how much it affects their career choices. The high school physics identity scale developed within the scope of the study will provide information about the high school physics identities of first year university students.

METHOD

In this study, a model was developed for investigating the effect of high school physics identities on career choices of university students, and a multi-factor complex predictive correlational design was used to examine the structural relationships between career outcome expectations, high school physics experiences, high school physics identities and career choices (Fraenkel, Wallen, & Hyun, 2011). The working group of this research is the first-year students of the Physics, Chemistry, Biology and Mathematics departments of the Faculty of Science and Arts at a state university and the Physics, Chemistry, Biology, Mathematics and Science Teaching Department of the Faculty of Education. 712 participants were included in the study. The responses of the participants to the data collection tools were subjected to pre-evaluation and 19 observations that left the child of the items blank (at least 5%) were excluded from the analysis. Analyzes were conducted with 693 participants. In the study, the High School Physics Identity Scale and the High School Career Outcome Expectations and Physics Experiences Questionnaire were used. High School Physics Identity Scale is a 5-point Likert type scale consisting of 22 items developed to measure the high school physics identities of university students. The validity and reliability studies of the scale were carried out by the researchers and it consists of 3 sub-dimensions: interest, recognition and competence-ability. The High School Career Outcome Expectations and Physics Experiences Questionnaire was also developed by the researchers to measure the high school career output expectations and physics experiences of university students and consists of 111 items.

RESULTS AND DISCUSSION

The model created to determine the factors affecting the High School Physics Identity is given below.

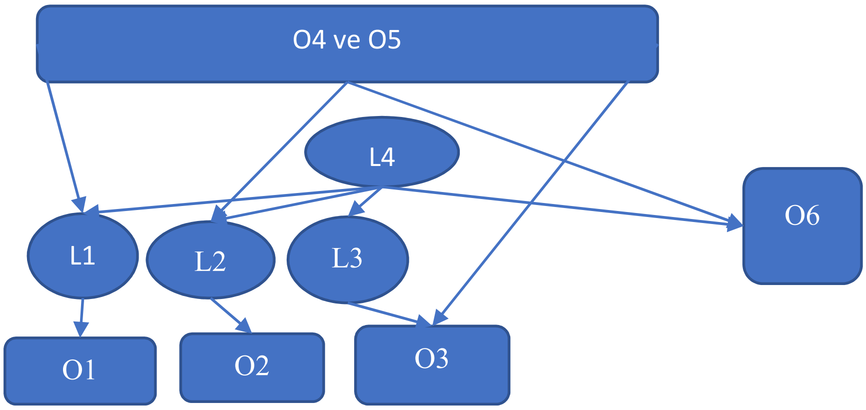

Figure 1. Generated Structural Equation Modelling for the research and the Path Diagram.

O1: Observed Variables 1 - Variables Forming Recognition Sub-Dimension; O2: Observed Variables 2 - Variables Forming Interest Sub-Dimension; O3: Observed Variables 3 - Variables Forming the Competence / Performance Sub-Dimension; O4: Observed Variables 4 - High School Career Outcome Expectations Variables; O5: Observed Variables 5 - High School Physics Experiences Variables; O6: Observed Variables 6 – Division/Program Variable; L1: Latent Variable 1 - Recognition; L2: Latent Variable 2 – Interest; L3: Latent Variable 3 - Competence / Performance; L4: Latent Variable 4 - High School Physics Identity

The hypothetical model created based on the relevant field literature and given in Figure 1 has been tested. All t values in the model obtained are statistically significant. After determining that the t values of the created model were statistically significant, the goodness of fit values of the model were evaluated. the goodness of fit indices of the physics identity measurement model can be said to be at the perfect fit (TLI=.935; CFI=.941; SRMR=.030; RMSEA=.029; $\chi 2/df = 1.51$). In this framework, it can be said that the model created as a result is confirmed. The coefficient of determination of the created and validated model was obtained as .165. According to this statistically significant result, the Physics Identity variable explains 16.5% of the variance in the department variable of the first-year university students forming the research group. The effect value of Physics Identity, which has a direct effect on the department they chose, was .406. Some other variables were found to have indirect positive effects and some indirectly negative effects.

In the relevant literature, it is stated that female students show a lower level of interest in science than male students. In this study, the high school physics identity scores of the female students were found to be higher than the scores of the male students. Peter and Horn (2015) stated that women's career interest in many fields has increased, but this interest has not yet turned to physics and engineering fields, and moreover Sadler et al. (2012) stated that gender difference in STEM career choices of male and female students is more prominent in the field of engineering rather than basic sciences.

When the high school physics identity scores of the students according to their departments are examined, the high school physics identity scores of the students studying in physics and physics teaching were found to be significantly different from the students of other departments. The difference between the scores of physics and physics teacher students is not significant.

This situation can be seen as an indication that high school physics identities have an effect on the choice of physics and physics teachers in choosing these departments. Again, it was determined that the high school physics identity scores of mathematics, mathematics teacher and science teacher students were significantly different from the high school physics identity scores of biology and chemistry students. This may be an indication that high school mathematics and physics courses affect the choice of career in physics and mathematics together. In parallel with this finding, Lock et al. (2013) state that mathematics interest positively affects physics career choice. Again, Godwin et al. (2016) stated that both physics and mathematics identity affect the career choice in engineering and Godwin et al. (2013) found in their structural equation modelling study that the engineering identity is formed by the effect of physics, mathematics and science identities.

Many other studies in the related literature (for example, Lock, Hazari, & Potvin, 2013; Hazari et al., 2010; Carlone & Johnson, 2007; Shanahan, 2007; Barton & Yang, 2000) also show that students' high school physics identities are effective in their career choices related to science. Again, Tai et al. (2006) found in their longitudinal study that middle school eighth grade students' high science identity predicted their choice of science career at university.

CONCLUSIONS AND RECOMMENDATIONS

This research has achieved mainly two conclusions. The first result is about whether the physics identity scores of students according to sex differ or not. Unlike other researches, in this study, girls had higher scores in physics identity and in all sub-identities than boys. This result, which is different from other researches, may be a new and different experience for researchers and teachers. The second conclusion is that physics identity is a strong predictor of students' career choice in areas related to basic sciences. This conclusion emphasizes the perceptions of students about physics and the importance of those perceptions on career preferences. These findings provide a basis for future research as well as directing educators and researchers to understand how they could affect students' physics identity.

Although there are sub-dimensions of interest, recognition, competence and performance in the conceptual framework of physics identity defined by Hazari et al. (2010), competence and performance dimensions could not be differentiated in this study and emerged as a single dimension. In other words, students see understanding physics and performing in physics as one thing. Studies can be conducted on why students cannot separate these two dimensions. Because, in the study of Carlone and Johnson (2007) with scientists, it was determined that these two dimensions were separated from each other. In the light of the findings obtained in that study, it can be suggested as a hypothesis that students combine understanding physics and performing in physics in one dimension due to the measurement and evaluation methods used. Future studies can be conducted in this direction.

The results of this study showed that physics identity development is a complex process and high school physics identity has an impact on career choice in basic sciences. The model obtained in this study, which reveals the high school physics identity scale and the factors affecting high school physics identity for university students, gives important clues for physics educators, other field educators, physics teachers, families and policymakers.

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REFERENCES

Barton, A. C., & Yang, K. (2000). The culture of power and science education: Learning from Miguel. *Journal of Research in Science Teaching*, 37(8), 871-889

Carlone, H. B. & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218. doi:10.1002/tea.20237

Gee, J.P. (2000). Identity as an analytic lens for research in education. *Review of Research in Education*, 25, 99–125.

Gillibrand, E., Robinson, P., Brawn, R., & Osborn, A. (1999). Girls' participation in physics in single sex classes in mixed schools in relation to confidence and achievement. *International Journal of Science Education*, 21(4), 349-362.

Erikson, E. (1980). *Identity and the life cycle*. New York: W. W. Norton.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2011). *How to design and evaluate research in education*. 8.th Edition. New York: McGraw-Hill.

Haussler, P., & Hoffmann, L. (2000). A curricular frame for physics education: Development, comparison with students' interests, and impact on students' achievement and self-concept. *Science Education*, 84(6), 689–705.

Hazari, Z., & Potvin, G. (2005). Views on female under-representation in physics: retraining women or reinventing physics? *Electronic Journal of Science Education*, 10(1).

Hazari, Z., Sonnert, G., Sadler, P. M., & Shanahan, M.-C. (2010). Connecting high school physics experiences, outcome expectations, physics identity, and physics career choice: A gender study. *Journal of Research in Science Teaching*, 47(8), 978–1003.

Irving, P. W., & Sayre, E. C. (2015). Becoming a physicist: The roles of research, mindsets, and milestones in upper-division student perceptions. *Physics Review Special Topics-Physics Education Research*, 11(2), 020120.

Lock, R. M., Hazari, Z., & Potvin, G. (2013, January). Physics career intentions: The effect of physics identity, math identity, and gender. In P. V. Engelhardt, A. D. Churukian, & N. S. Rebello (Eds.), *AIP Conference Proceedings* (Vol. 1513, No. 1, pp. 262-265). AIP.

Oon, P. T., & Subramaniam, R. (2011). On the declining interest in physics among students—from the perspective of teachers. *International Journal of Science Education*, 33(5), 727-746.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections* (Vol. 13). London: The Nuffield Foundation.

Peter, K., & Horn, L. (2005). *Gender differences in participation and completion of undergraduate education and how they have changed over time*. National Center for Educational Statistics Report, NCES 2005169. http://nces.ed.gov/pubsearch/pubsinfo.asp?pubid=2005169.

Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, 96(3), 411-427.

Seymour, E., & Hewitt, N. (1997). Talking about leaving. Boulder, CO: Westview Press

Shanahan, M.C. (2007) *Playing the role of a science student: Exploring the meaning of the science student role and its relationship to students' identification in science*. Unpublished doctoral dissertation, Ontario Institute for Studies in Education, University of Toronto.

Tai R.H., Liu C.Q., Maltese A.V., & Fan X. (2006) Planning early for careers in. *Science*, 312 (5777),1143–1144. doi:10.1126/science.1128690

Tyson, W., Lee, R., Borman, K. M., & Hanson, M. A. (2007). Science, technology, engineering, and mathematics (STEM) pathways: High school science and math coursework and postsecondary degree attainment. *Journal of Education for Students Placed at Risk*, 12(3), 243-270.
Woolnough, B. E. (1994). Why students choose physics, or reject it. *Physics Education*, 29(6), 368.

AN INFORMAL PHYSICS CLUB WITH YOUNG WOMEN LEADERSHIP: A COUNTERSPACE FOR DEVELOPING PHYSICS IDENTITY

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Research shows that by the time female students reach high school age they are much less likely than other students to see themselves as "physics people," and are less interested in pursuing physics majors or physics-related careers as they enter higher education. This lack of interest, which is often the result of societal and cultural factors, contributes to the persistent marginalization of women in physics. In addressing this historical problem, physics teachers can play a critical role in engaging young women and challenging stereotypic ways of thinking about and doing physics. In particular, by disrupting traditional cultural messaging and norms, teachers can facilitate young women's physics identity development. However, the existing culture of power in many physics classrooms, structural constraints of formal schooling, and often restricted curriculum may not provide a safe space for female students to enact physics identities in ways that are personally meaningful. Thus, we argue that counterspaces beyond existing classrooms are needed to create and sustain engagement. In this exploratory investigation, we examined the characteristics of an informal physics club initiated by a high school physics teacher and run by his female students to understand if and how this club emerged as a counterspace that promotes physics identity development for female students. This paper focuses on data from a focus group interview with five leaders of the club and the physics teacher. We show that recognizing and celebrating communal goals in this club, along with young women's leadership, were important factors in creating a counterspace for physics identity development. As such, we recommend establishing these types of informal physics learning spaces as counterspaces that can facilitate the development and expansion of physics identities among female students.

Keywords: Non-formal Learning Environments, Gender Issues, Physics

INTRODUCTION

Studies have highlighted the persistent underrepresentation of women in physics as well as the depressed opportunities for young women's physics identity construction (Hazari, Cass, & Beattie, 2015; Wang & Hazari, 2018). As a consequence, by the time female students reach high school age, they are much less likely than their male counterparts to see themselves as "physics people" (Nissen, 2019). Despite this fact, female students who choose to continue their physics education in college have been found to be strongly affected by their high school physics experiences (Hazari, Brewe, Goertzen, & Hodapp, 2017). This finding indicates that physics teachers can and do play a critical role in reversing a downward trend in attitudes towards physics. As such, a national project was launched to mobilize high school physics teachers to begin addressing deep-seated historic issues of gender bias and facilitate physics identity development, particularly for female students (Cheng et al., 2018; Potvin et al., 2022). Drawing from critical race and feminist theories, the resources provided by this project focus on presenting counternarratives that disrupt normative stereotypic narratives about who does physics and what physics is. These classroom resources have been shown to have significant positive effects for female students' physics identity development and intentions to continue studying physics (Cheng et al., 2018). However, the existing normative nature of school science often transmits a culture of power (e.g., curricular boundaries, lack of student agency, teacher-centeredness) (Barton & Yang, 2000). Therefore, it is difficult to sustain counternarratives or disruptions to normative identities/content/practices without creating new spaces. Prior work, which mainly focused on the college-level or workplace, found that "counterspaces" were a critical solution for establishing and sustaining counternarratives (Ong, Smith, & Ko, 2018).

COUNTERSPACES, COUNTERNARRATIVES & COUNTERSTRUCTURES

Solorzano, Ceja, and Yosso (2000) defined counterspaces as spaces in which there are active or proactive attempts to prevent the reproduction of marginalizing patterns and that allow minoritized groups to engage in learning and reflect on their experiences in ways that help grow their sense of belonging and nurture their multiple identities. In the context of physics education, counterspaces can create an environment where historically marginalized groups (e.g., young women) can develop a shared physics identity beyond the normative stereotypic constructions. Ong et al. (2018) posit that counterspaces are a critical refuge from negative and marginalizing experiences in STEM, such as microaggressions and low sense of belonging, that lead minoritized groups to disengage from the discipline.

Within counterspaces, counternarratives that resist stereotypic ways of doing physics emerge and are supported. For example, physics is not perceived to be communal, either in terms of learning (e.g. working together) or what goals are valued by the field (e.g. helping others/society), but is perceived as individualistic, where demonstrating "innate ability" or individual mastery are centralized in both the learning process and what is valued (Carlone, 2004; Kessels, Rau, & Hannover, 2006; Leslie, Cimpian, Meyer, & Freeland, 2015). These normative patterns of what it means to learn physics and how that learning occurs can be disrupted within counterspaces creating new counternarratives about physics learning.

We also draw on the concept of a counterstructure, which can be conceived as a characteristic of counterspaces. It is defined as active institutionalized attempts to support marginalized groups' efforts by shifting control from brokers of power within traditional structures (e.g., white males, teachers) and centering agency and control amongst the marginalized (Lee & Harris, 2020). In traditional science classes, including physics, normative power structures typically prevail due to the constraints imposed by historic educational and curricular standards and expectations (Barton & Yang, 2000). Thus, counterspaces are often necessary to enable counterstructures of power to form and over time influence change in other spaces. Guided by these theoretical concepts, we examine the development and impact of an informal physics club for female students that was initiated by a high school physics teacher. This exploratory investigation examines how the club served as a counterspace for physics identity development and if and how counternarratives and counterstructures were supported.

METHOD

As an exploratory investigation into a physics club of predominantly Latinas (that had been independently initiated by a physics teacher and which had rapidly grown over three years), we conducted a narrative-focused group interview to begin understanding the ways in which this club may be creating a counterspace for young women of color. Previously we had informal conversation with the physics teacher and administered a pre-post survey on physics identity among club members. However, the data for this study came from a 90 minutes focus group interview. The interview was conducted with the physics teacher and five student club leaders, all-female, four in 12th grade, and one in 11th grade. All the students self-identified as Hispanic. Guided by our theoretical lenses, we used thematic analysis (Clarke & Braun, 2017) to identify features of the club that promoted physics identity development through shared multiple identities and sense of belonging among the members (counterspace), non-normative narratives with respect to physics and physics learning (counternarratives), and agential non-dominant structures (counterstructures). In the next sections, we introduce Mr. S, the physics teacher, and what inspired him to start a physics club, followed by findings of the analysis and emerging themes. Note that emphasis (bolding) in the quotes was added to illustrate central points related to the themes.

HOW THE PHYSICS CLUB STARTED

Mr. S was a teacher we had worked with as part of a larger study and contributed to the development of equitable/inclusive class resources. He has been implementing these co-created resources in his physics classes for four years (and still continues). Mr. S's background is in engineering and physics, and he has more than 35 years of experience teaching physics and other science courses (e.g., environmental science). His school is located in a large urban district with a high representation of Hispanic students (more than 90 percent). Prior to the physics club, Mr. S started an engineering club as part of the Southeastern Consortium for Minorities in Engineering (SECME). But since his participation in our larger study, he felt the need to go beyond the confinement of curriculum and class time to better engage and encourage his students, particularly young women, towards their physics learning and career pathways.

> The club is just to promote, just to do activities in the school and [...] students can see those activities. [...] I promote [physics] to everybody. **But the girls**, after the second lesson[10], **they're going to feel more attraction for [physics]** and [...] they realize they can do it. [The] lesson basically motivate many of my students to be part of the physics club. They ask me about that [...] **then I start to talk to them to participate in the club.**

[10] Mr. S refers to the Women in Physics Lesson, one of the class resources developed in our larger project. The lesson challenges narratives that relate physics to masculinity and frame physics as an individualistic pursuit of "pure" science as opposed to a culturally driven field and community and exposes the structural and cultural barriers that prevent many individuals, particularly women, from pursuing physics. Read more about it in Sabouri et al. (2022) and refer to the website for the full lesson (APS engage, 2022).

The club started with about 16 members and over three years it grew to 27, which was when we conducted the focus group interview. The club activities included participating in workshops, attending presentations by invited speakers from universities, organizing career fairs and science nights for parents and students, and participating in regional and national science competitions. These activities can be characterized as normative types of physics activities (e.g., competition or presentation). However, after analyzing the interview transcription, two themes emerged indicating how the club was a counterspace with a counterstructure promoting new ways of learning physics, hence disrupting normative narratives of physics: (1) the leadership by young women, and (2) the communal culture of the club. Next, we further explain these themes and present evidence from the interview data.

GIRLS' LEADERSHIP CREATED A COUNTERSTRUCTURE

Since the establishment of the club, Mr. S has been purposefully encouraging his female students to join the club. Moreover, he identified those with strong leadership skills and invited them to take the club's management role (e.g., president).

> I give [my female students] the chance to have the position, [...]according to the history in this school, I really like to give [them] **an opportunity** [...] **that I think they deserve**. […] (Mr. S)

In addition to nurturing their skills and potentials, by positioning the young women as leaders, Mr. S anticipated that other students would see them as a role model which would encourage them to participate in club activities and experience physics learning, although they might not necessarily feel comfortable or confident to do so.

> If we do organize a club with a very good leadership, like [these students] are, **they [become] examples, you know, as a student**. [They] are responsible and **the other students see them as leaders** [and] they see that they can [be] [...] I know if I do this, we are gonna have a lot of people here [in the club]. (Mr. S)

Mr. S's recognition was not hidden but visibly noticed and acknowledged by the members.

> Mr. S approached me and (Angela) […] he asked us both because …well, I assume **he liked our work and how we work together** [...] he asked us to be president and vice president of the [club]" (Blanca).

Prior research studies showed that teachers' recognition in ways that are meaningful for students is a strong predictor of whether they identify as a physics person, someone who can learn and do physics (Hazari et al., 2017; Wang & Hazari, 2018). Drawing on these findings, in this club, we state that Mr. S's recognition and encouragement facilitated students' physics identity development, and that motivated other students, in particular female students, to join the club.

> I remember having a friend of mine **at first, she was so confused and she didn't understand Physics**. And then [...] she entered the [club] and actually organized the stuff and everything, she was just like… This is really interesting. And it's not as complicated as I thought (Cara)

By positioning female students as club leaders, Mr. S shifted the typical power structure, often seen in STEM clubs, where male students overtake the decision-making and material manipulation (Witherspoon, Schunn, Higashi, & Baehr, 2016). Cara, who did not initially see herself as a physics person, took on a leadership role (organized) which helped her more meaningfully engage in a way that she directed for herself. We argue that designating leadership positions (at least initially) to female students and recognizing their skills created a counterstructure for this club, which led to bringing other young women into the club to engage with physics learning and take leadership in this space.

COMMUNAL GOALS & AMBASSADORSHIP PROMOTE COUNTERNARRATIVES

Two existing narratives around physics are: (1) it is an individualistic field as opposed to a collaborative and communal discipline (Bruun, Willoughby, & Smith, 2018; Kessels et al., 2006), and (2) it positions innate ability found in a dominant group, mainly white males, or exceptional cases of other groups (e.g. women) as superior and necessary for learning and succeeding in physics (Archer, Moote, Francis, DeWitt, & Yeomans, 2017; Leslie et al., 2015). These normative narratives around physics often discourage female students, unconsciously and consciously, from engaging in learning physics (Diekman, Brown, Johnston, & Clark, 2010). In contrast, in this physics club, both of these narratives were challenged and disrupted.

> [T]he people in the club […] **were really welcoming. And if you didn't know the subject they would teach you**, help you to understand more. And that sense of community also really helps me […] want to stay here and I want to help others to understand and be more interested […], to share that common… like in the subject. (Cara)

Instead of identifying certain types of talents or "ability" in physics, the club members welcomed everyone and supported each other in learning physics. The "sense of community" as opposed to competing established the club as a counterspace. Moreover, members recognized the communal culture as a vibe of the club:

> …all of us in the club have that dedication, that time management, that ability to be flexible for the club and be able to stay after school and **show a love for the club** through lab demonstrations, **through helping other classmates with physics work**. (Angela)

These young women not only saw the club as a safe space to expand their physics identity and create engaging and meaningful learning environments for themselves, but they also became motivated to inspire others to pursue and persist in learning physics.

> I had this fire to show that women can also do it, to show others who have that idea and that stigma […] women aren't really seen and they shouldn't be in it. So that would **draw me to help the club be the best** it can just to show everyone that minority such as women and Latinos can also be a major role in Science." (Angela).

Angela felt that it was important to be an ambassador for others to disrupt normative notions about women and LatinX students' place in physics. Together with the communal focus of the club, this became a way in which the club promoted counternarratives that resisted dominant narratives about who does physics and how it is done.

CONCLUSION

Several research studies have shown the effectiveness of informal science programs (e.g., afterschool or summer camp) as a way of engaging young women in science learning and developing their science identities (Adams & Gupta, 2017; Riedinger & McGinnis, 2017). However, a limited number of studies have focused on physics learning and mainly explored the impact of informal programs on college-level students (Fracchiolla, Prefontaine, & Hinko, 2020; Hazari, Dou, Sonnert, & Sadler, 2022; Prefontaine et al., 2021). In this study, we aim at addressing this gap in the literature by examining the characteristics of an informal physics club that facilitated female students' engagement in physics activities and learning, particularly in ways that might disrupt normative conceptions.

The theoretical lens of counterspaces, and within them, counterstructures and counternarratives, guided our exploratory study utilizing a focus group interview with club leaders and the founding physics teacher. We learned that designating leadership positions to young women disrupted the normative power structure and created a counterstructure for this club. Unlike formal physics/science classrooms, where male students often dominate the conversation and the flow of the activities (Wieselmann, Dare, Ring-Whalen, & Roehrig, 2020), in this club female students were responsible for decision-making and setting the norms. This counterstructure, initiated by the teacher, encouraged female students who may not have seen themselves as a physics person to engage in the club and shifted their views about physics learning. Prior work in physics has shown that certain types of leadership ("inchargeness") can actually lead to more equitable interactional outcomes such as when the student leader distributes voice to others (Jeon, Kalender, Sayre, & Holmes, 2020). Similarly, the club under the leadership of highly communal young women became a counterspace for facilitating and nurturing female students' physics identity development. Additionally, all five club members emphasized that pursuing and promoting communal goals were at the heart of the club. The establishment of a collaborative and communal culture allowed the emergence of counternarratives about physics which, as a result, was encouraging others to join the club and see themselves as physicists.

We acknowledge the limitations of this small exploratory study and do not claim the generality of these results. Furthermore, while there were non-normative constructions of physics learning in the club, many normative approaches to physics were also upheld. For example, more work is needed to better understand how normative physics content can be disrupted within informal spaces. However, theorizing how structures/experiences within this particular club facilitated the development of a counterspace is important; by leading the club's activities, these young women created a joyful, safe and meaningful learning space for themselves. As such, we recommend that counterspaces with similar counterstructures in informal STEM education might provide a critical opportunity for challenging and disrupting normative physics narratives that marginalize young women from participation and pursuit of physics.

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REFERENCES

Adams, J. D., & Gupta, P. (2017). Informal science institutions and learning to teach: An examination of identity, agency, and affordances. *Journal of Research in Science Teaching, 54*(1), 121-138. doi:https://doi.org/10.1002/tea.21270

APS Engage. (2022). STEP UP Physics. American Physical Society Engage WEbsite. Retrieved from https://engage.aps.org/stepup/curriculum

Archer, L., Moote, J., Francis, B., DeWitt, J., & Yeomans, L. (2017). The "exceptional" physics girl:A sociological analysis of multimethod data from young women aged 10–16 to explore gendered patterns of post-16 participation. *American Educational Research Journal, 54*(1), 88-126. doi:10.3102/0002831216678379

Barton, A. C., & Yang, K. (2000). The culture of power and science education: Learning from Miguel. *Journal of Research in Science Teaching, 37*(8), 871-889. doi:https://doi.org/10.1002/1098-2736(200010)37:8<871::AID-TEA7>3.0.CO;2-9

Bruun, M., Willoughby, S., & Smith, J. L. (2018). Identifying the stereotypical who, what, and why of physics and biology. *Physical Review Physics Education Research, 14*(2), 020125. doi:10.1103/PhysRevPhysEducRes.14.020125

Carlone, H. B. (2004). The cultural production of science in reform-based physics: Girls' access, participation, and resistance. *Journal of Research in Science Teaching, 41*(4), 392-414. doi:https://doi.org/10.1002/tea.20006

Cheng, H., Potvin, G., Khatri, R., Kramer, L., Lock, R., & Hazari, Z. (2018). *Examining physics identity development through two high school interventions.* Paper presented at the Proceeding of Physics Education Research Conference.

Clarke, V., & Braun, V. (2017). Thematic analysis. *The Journal of Positive Psychology, 12*(3), 297-298. doi:10.1080/17439760.2016.1262613

Diekman, A. B., Brown, E. R., Johnston, A. M., & Clark, E. K. (2010). Seeking congruity between Goals and roles: A new look at why women opt out of science, technology, engineering, and mathematics careers. *Psychological Science, 21*(8), 1051-1057. doi:10.1177/0956797610377342

Fracchiolla, C., Prefontaine, B., & Hinko, K. (2020). Community of practice approach for understanding identity development within informal physics programs. *Physical Review Physics Education Research, 16*(2), 020115. doi:10.1103/PhysRevPhysEducRes.16.020115

Hazari, Z., Brewe, E., Goertzen, R. M., & Hodapp, T. (2017). The importance of high school physics teachers for female students' physics identity and persistence. *The Physics Teacher, 55*(2), 96-99. doi:10.1119/1.4974122

Hazari, Z., Cass, C., & Beattie, C. (2015). Obscuring power structures in the physics classroom: Linking teacher positioning, student engagement, and physics identity development. *Journal of Research in Science Teaching, 52*(6), 735-762. doi:https://doi.org/10.1002/tea.21214

Hazari, Z., Dou, R., Sonnert, G., & Sadler, P. M. (2022). Examining the relationship between informal science experiences and physics identity: Unrealized possibilities. *Physical Review Physics Education Research, 18*(1), 010107. doi:10.1103/PhysRevPhysEducRes.18.010107

Jeon, S. M., Kalender, Z. Y., Sayre, E. C., & Holmes, N. G. (2020). How do gender and inchargeness interact to affect equity in lab group interactions? In *2020 Physics Education Research Conference Proceedings*.

Kessels, U., Rau, M., & Hannover, B. (2006). What goes well with physics? Measuring and altering the image of science. *British Journal of Educational Psychology, 76*(4), 761-780. doi:https://doi.org/10.1348/000709905X59961

Lee, E. M., & Harris, J. (2020). Counterspaces, counterstructures: Low-income, first-generation, and working-class students' peer support at selective colleges. *Sociological Forum, 35*(4), 1135-1156. doi:10.1111/socf.12641

Leslie, S. J., Cimpian, A., Meyer, M., & Freeland, E. (2015). Expectations of brilliance underlie gender distributions across academic disciplines. *Science, 347*(6219), 262-265. doi:10.1126/science.1261375

Nissen, J. M. (2019). Gender differences in self-efficacy states in high school physics. *Physical Review Physics Education Research, 15*(1), 013102. doi:10.1103/PhysRevPhysEducRes.15.013102

Ong, M., Smith, J. M., & Ko, L. T. (2018). Counterspaces for women of color in STEM higher education: Marginal and central spaces for persistence and success. *Journal of Research in Science Teaching, 55*(2), 206-245. doi:https://doi.org/10.1002/tea.21417

Potvin, G., Hazari, Z., Khatri, R., Cheng, H., Lock, R., Kornahrens, A., . . . Hodapp, T. (2022). Examining the effect of counter-narratives about physics on women's physics career intentions. *Physical Review Physics Education Research*, In review.

Prefontaine, B., Mullen, C., Güven, J. J., Rispler, C., Rethman, C., Bergin, S. D., . . . Fracchiolla, C. (2021). Informal physics programs as communities of practice: How can programs support university students' identities? *Physical Review Physics Education Research, 17*(2), 020134. doi:10.1103/PhysRevPhysEducRes.17.020134

Riedinger, K., & McGinnis, J. R. (2017). An investigation of the role of learning conversations in youth's authoring of science identities during an informal science camp. *International Journal of Science Education, Part B, 7*(1), 76-102. doi:10.1080/21548455.2016.1173741

Sabouri, P., Hazari, Z., Barnett Dreyfuss, B., & Khatri, R. (2022). Considerations for inclusive and equitable design: The case of STEP UP counternarratives in high school physics. *The Physics Teacher, In print*.

Solorzano, D., Ceja, M., & Yosso, T. (2000). Critical race theory, tacial microaggressions, and campus racial climate: The experiences of african american college students. *The Journal of Negro Education, 69*(1/2), 60-73. Retrieved from http://www.jstor.org/stable/2696265

Wang, J., & Hazari, Z. (2018). Promoting high school students' physics identity through explicit and implicit recognition. *Physical Review Physics Education Research, 14*(2), 020111. doi:10.1103/PhysRevPhysEducRes.14.020111

Wieselmann, J. R., Dare, E. A., Ring-Whalen, E. A., & Roehrig, G. H. (2020). "I just do what the boys tell me": Exploring small group student interactions in an integrated STEM unit. *Journal of Research in Science Teaching, 57*(1), 112-144. doi:https://doi.org/10.1002/tea.21587

Witherspoon, E. B., Schunn, C. D., Higashi, R. M., & Baehr, E. C. (2016). Gender, interest, and prior experience shape opportunities to learn programming in robotics competitions. *International Journal of STEM Education, 3*(1), 18. doi:10.1186/s40594-016-0052-1

SCIENCE EDUCATION FOR THE DEAF: THE USE OF THE MUSEUM TO PROMOTE POPULARIZATION OF SCIENCE

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This work aims to understand how Science Museums can promote the popularization of science, with focus on deaf visitors, through a case study conducted in Brazilian museums. Teaching science to deaf students in Brazil represents a challenge in Brazilian schools considering the lack of sign in the Brazilian Sign Language (Libras), causing the scientifical exclusion of deaf students in the process of learning and teaching science. Considering that, teaching science to deaf persons can make use of complementary resources, like Science Museums. Those are informal education spaces that acts on subjective aspects and allows the construction of collective identity, allowing the inclusion and, consequently, the popularization of science to the deaf community. This case study considers interviews with three professionals that work in Brazilian Science Museums and attend deaf visitor and was analysed by Analysis Content, and result in four categories, namely Measures of Accessibility, Visibility, Exclusion Factors and Access to knowledge. With this research, it was possible to recognize how Science Museums have promoted the inclusion of the deaf community through activities of Popularization of Science, but it was recognized that the development of research in the inclusion of the deaf in the field of science still needs to be carried out, in addition to projects to include this community in informal educational spaces, such as Museums and Science Centers.

Keywords: Inclusion. Informal Learning. Science Education.

THE POPULIZATION OF SCIENCE TO DEAF PERSONS IN BRAZIL

Teaching science to deaf students in Brazil represents a challenge, considering the lack of sign in the Brazilian Sign Language (Libras) that correspond to scientific terms (Rumjanek, 2011). The main cause is the historical scientific exclusion of deaf students in process of learning and teaching science, as described by Rumjanek (2011, p. 19) that says that "the exclusion of deaf on the scientific process made Libras be poor in scientific and technological terms, hindering the bilingual teach of science". Besides that, the complexity of the scientific concepts and the need of abstraction required to understand those concepts are also considered a challenge to teach science to deaf students.

Considering that issues, teaching science to deaf persons need to be made in their own sign language (Quadros, 1997) and make use of complementary resources, like visual elements and the use of different educational spaces, like Museums of Science and Technology (Gomes, Catão & Soares, 2015). Those spaces can arouse interest in science (Cnpq, 2015), becoming allies for science education aimed at deaf students, since they have a strong visual appeal, favouring discussions about scientific content.

Museums as allies to Science Education for Deaf visitors

Museums are informal educational spaces, it means that they are, by definition, different environments comparing to the school, and the process of education in these spaces occurs through "processes of sharing experiences" (Gohn, 2006, p.28). Besides that, the informal education acts on subjective aspects and allows the construction of collective identity, which is "one of the great highlights of informal education today" (Gohn, 2006, p.29).

Many Brazilian science museums are concerned about the need of producing content in English for its exhibitions ensuring accessibility for foreign visitors. However, the same doesn't occur with Libras, the language of the Deaf community in Brazil, making the Deaf visitor feel like a foreigner in their own country, in a space inaccessible to them (Silva, Rojas & Teixeira, 2015). Thus, when the Deaf community has limited access to places that are social reference, frequented by Brazilian and even foreign visitors, they become socially vulnerable, failing to fully participate in the society in which they live, which leads to their exclusion (Aidar & Chiovatto, 2011).

Thinking about the inclusion of these visitors and promote science education, Chalhub, Benchimol & Rocha (2015, p.4) suggest that Museums can afford "the presence of fluent employees in the sign; the presence of guide interpreters for the deaf in the exhibitions; presence of video-guide, with signs and subtitled, explaining the exhibition; presence of SignWriting (sign language writing) explaining the exposed collection" and others. Thus, in addition to inclusion, Museums are also strong allies in science teaching because the proposals related to science teaching bring the need for the active involvement of students in the activities developed in those spaces.

CASE STUDY

Identifying the challenges described above, we carried out a qualitative survey to understand how Science Museums can promote the science popularization, with focus on deaf visitors, developing a case study with three professionals that work in Brazilian Science Museums and attend deaf visitors. Semi-structured interviews were conducted online and analyzed by content analysis, described by Laurence Bardin in 1979, between the months of July and August 2020.

To select the sample of professionals and educators who work with science popularization aimed at the Deaf in Museums and Science Centers, a search was carried out for accessible Brazilian spaces through the Guide to Accessible Science Centers and Museums in Latin America and from the Caribbean (Norberto Rocha *et al.,* 2017), carried out by the Accessible Science Centers and Museums Group (MCCAC Group). In this guide, there are identified 69 accessible scientific spaces in Brazil of which 18 present some type of activity for the Deaf. Considering the characteristics of each one, we selected three Brazilian spaces that promotes science popularization activities for Deaf visitors, namely: *Fundação Planetário da Cidade do Rio de Janeiro*, *Centro de Ciências da Universidade Federal de Juiz de Fora* and *Espaço do Conhecimento da Universidade Federal de Minas Gerais*.

After the interviews, the content analysis was carried out, which is a deductive and inferential process regarding the understanding of a given message and is divided into three chronological poles: pre-analysis; exploration of material and treatment of results, inference and interpretation (Bardin, 2011), resulting in four categories, described below.

RESULTS

The interviews were analysed by Content Analysis and resulted in a total of 321 registration units (R.U.). This data was organized into categories, originating 29 initial categories, which were again grouped into 12 intermediate categories to finally obtain four final categories: Accessibility Measures, Visibility, Exclusion Factors and Access to Knowledge (Table 1).

Table 1. Total categories and frequency.

Final Category	Intermediate Category	R.U.	Frequency (%)
Accessibility Measures	Accessibility measures	110	34,4
	Specialized service		
	Partnerships with institutions and employees		
	Opportunities for deaf visitors		
Visibility	Representativeness	88	27,4
	Personal Motivation		
	Dissemination		
Exclusion Factors	Lack of accessibility and visibility	78	24,3
	Impediments		
	Prejudice		
Access to Knowledge	Science popularization	45	14
	Expansion of access		

Font: Authors (2021).

Below are described the results of each category.

Accessibility Measures

The first category addresses measures related to accessibility in museum, considering the importance of having a specialized service, the realization of partnerships with institutions, employees and schools and the opportunities that are created to allow this accessibility. This category represents 34% of the total. Four intermediate categories were identified within Category 1. One, which gives this category its name, *accessibility measures*, addresses aspects related to attitudes, activities and efforts to allow accessibility in the studied science spaces that promotes de access to the knowledge and, consequently, the popularization of science. Among these measures, is the investment in accessibility and the production of accessible content. Another intermediate category refers to the *specialized service* that is dedicated to the deaf visitors. For this service, it should be considered, among other things, the realization of qualification and training with employees, as well as addressing issues related to their behavior towards deaf visitors. In order to allow the application of some accessibility measures, it was considered relevant to establish *partnerships with institutions and employees* who can assist in the development of inclusion activities. To conclude this category, it is also important to discuss *opportunities for deaf visitors* to work and those spaces, that are the result of the accessibility measures adopted.

With this category, it was possible to identify measures related to accessibility in museum spaces through attitudes, activities and efforts to provide access to all, considering the importance of having specialized care, establishing partnerships with institutions, employees and schools.

Visibility

The second category brings together aspects related to the visibility of the deaf and the Brazilian Sign Language and includes the personal motivations of the researchers and the interest in expanding access to the deaf through dissemination in digital media, favouring the visibility of inclusion activities that can arouse interest in science. This category corresponds to 27.4% of the total. This category is divided into the intermediate categories: *representativeness*, which is perceived when there is a recognition of the deaf person and his needs in these spaces, and which is reflected in the attitudes that are taken when attending them. It also discusses the personal experiences of the participants that led to decisions for the development of accessible activities, which expresses this concern with the accessibility to the science knowledge. Considering the visual aspects of museums, it is possible to adapt them to be more accessible to the deaf community, leading to their inclusion, promoting the popularization of science. The intermediate category called *personal motivation* is also part of Visibility, as it discusses the processes of searching for knowledge and the Motivations and personal concern that employees had and that made them seek accessibility measures. Finally, the intermediate category called *dissemination* addresses alternatives for reaching the deaf community, through dissemination of science measures on websites, apps, advertisements, in order to reach the deaf audience and thus make inclusion activities effective.

With this category, it was possible to understand how researchers' personal motivations and the interest in expanding access to the Deaf can promote the visibility. These professionals demonstrated an involvement that goes beyond the barrier of their work assignments, seeking alternatives that reach the Deaf public, even during the pandemic period. For this, they promote it on websites and social networks as a tool to reach the Deaf community and thus make inclusion activities effective.

Exclusion Factors

The third category addresses the exclusion factors considered by the participants, which are important for identifying the barriers that reduce the accessibility, and, consequently, the access of science knowledge, as well as attitudes that demonstrate prejudice and lead to exclusion. Category three represents 24,3% of the total. The *lack of accessibility and visibility* were the most frequent exclusion factors, in line with the communication difficulties resulting from this lack of accessibility. Some *impediments* were identified as exclusion factors, such as the closure of activities aimed at the deaf community, the lack of interest from organs and employees in popularization of science measures and the high cost of certain activities, which end up being closed due investment difficulties. Finally, it was recognized that *prejudice* is one of the exclusion factors while preventing visitation and excluding this community from cultural and scientifical activities.

This category managed to expose some of the barriers that reduce and impede access to these places, such as the lack of accessibility, visibility and difficulties in communication, as well as the presence of attitudes that reveal prejudice. This exclusion was also identified from the end of activities aimed at the Deaf community, due to the lack of interest of agencies and employees and the high cost demanded by some of them.

Access to Knowledge

Finally, the fourth category addresses issues related to access to knowledge, considering factors for expanding access and popularizing science, corresponding to 14% of the total. The last category recognized from the interviews addresses issues related to access to knowledge. This category has two intermediate categories: the *science popularization*, which brings together the statements related to measures to expand access to science, through the dissemination and popularization of science, and the subcategory *expansion of access*, which brings together aspects related to the frequency of visitation and measures to expand access on informal education spaces. The popularization of science is also related to the accessibility of terms and concepts, as, according to Moda (2017), the Deaf visitor can present difficulties in the formation of scientific concepts, due to issues related to language or lack of preparation in training employees for this attendance.

With this category, it was found that, in order to allow access to knowledge, attitudes should be developed to expand this access through science dissemination and popularization, considering that one of the functions of scientific communication is taking science to places where it is not accessible. The carrying out of educational activities in informal educational spaces can arouse interest in science, promoting the development of scientific culture and favouring the dissemination of science into the Deaf community, mainly due to its strong visual appeal. It was discussed that the realization of scientific literacy workshops and activities in non-formal educational spaces favours the visual experience of the Deaf visitor, making science understandable and meaningful for this visitor.

CONCLUSIONS

In this work, we approached the issue of education for the deaf in Brazil and we realized that even with the advances, the scientific educational process is compromised due to the greater investment in other disciplines, if not science. As discussed, this results in the restriction of the inclusion of deaf people in the scientific field and the deficit in the development of new signs in the area, which causes difficulties in teaching science, leading to scientific exclusion. From these considerations, we highlight the importance of using visual and spatial elements in the education of the Deaf. Thus, we suggest the use of different educational spaces, such as the Science Museums, to assist this process, as they have visual and interactive elements necessary for the education of the deaf, in addition to addressing the scientific content in a playful and interactive way.

Furthermore, we realize that from their scientific bias, Science Museums can contribute to the education of the deaf community in Brazil through activities aimed at social inclusion through science, by the popularization of science. The Content Analysis, which was carried out through interviews with three professionals and educators who work with Popularization of Science accessible to Deaf visitors in Science Museums, allowed to identify the relationship between the activities carried out in Science Museums and research on Popularization of Science. Science focused on the Deaf in these spaces.

With all the considerations so far, we believe that it was possible to recognize how Science Museums have promoted the inclusion of deaf visitors through activities of Popularization of

Science, but we also recognize that more research is needed in the area of the inclusion of deaf people in the field of science, in addition to projects for the inclusion of this community on informal educational spaces, such as Science Museums.

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REFERENCES

Aidar, G.; Chiovatto, M. (2011). Interligar o museu e seu entorno: a ação educativa extramuros da Pinacoteca do Estado de São Paulo. *Revista de Ciências da Educação*, 1(25), 1–21.

Bardin, L. (2011). *Análise de conteúdo*. São Paulo: Edições 70.

Chalhub, T., Benchimol, A. & Rocha, L. M. (2015). Acessibilidade e Inclusão: a informação em Museus para os Surdos. *XVI Encontro Nacional de Pesquisa em Ciência da Informação*.

CNPq. (2015) *Conselho Nacional de Desenvolvimento Científico e Tecnológico*. Por que popularizar? (Online).

Gohn, M. G.(2006). Educação não-formal, participação da sociedade civil e estruturas colegiadas nas escolas. *Ensaio: Avaliação e Políticas Públicas em Educação*, 14 (50), 27–38.

Gomes, E. A., Catão, V. & Soares, C. P. (2015). Articulação do conhecimento em museus de Ciências na busca por incluir estudantes Surdos: analisando as possibilidades para se contemplar a diversidade em espaços não formais de educação. *Experiências em Ensino de Ciências*, 10(1), 81–97.

Norberto Rocha, J., Massarani, L., Gonçalves, J. C., Ferreira, F. B., Abreu, W. V., Molenzani, A. O. & Inacio, L. G. B. (2017). *Guia de Museus e Centros de Ciências Acessíveis da América Latina e do Caribe.* Rio de Janeiro: Museu da Vida/Casa de Oswaldo Cruz/Fiocruz: RedPOP; Montevidéu: Unesco.

Rumjanek, J. B. D. (2011). *Novos sinais para a ciência:* desenvolvimento de um glossário científico em Libras (Master's thesis, Universidade Federal do Rio de Janeiro, Rio de Janeiro).

Quadros, R. M. (1997). *Educação de Surdos*: A aquisição da linguagem. Porto Alegre: Artmed.

Silva, J. P. F.; Rojas, A. A.; Teixeira, G. A. P. B. (2015). Acessibilidade comunicacional aos Surdos em ambientes culturais. *Conhecimento & Diversidade*, 1(13), 103–115.