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Will all students benefit if we involve more senses in their lessons?

A proposal of activities and strategies for multisensory instruction into primary schools

Senior Thesis

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To my father, who we lost in January. He loved taking care of his garden full of flowers, and brought inspiration for this project. I hope he would be proud to see me bloom as a teacher.

ABSTRACT

Multisensory methodologies were developed as an educational response for children in the SEN context in order to stimulate various senses simultaneously targeting each student's learning strengths. The following study aims to verify if the application of the activities and strategies in the guide designed, based on empirical findings, is efficient in a non-special education school context, improving all learner's knowledge and behaviours and raising teacher's confidence and willingness to apply more inclusive and multisensory methodologies in their classroom. The sample is compound of 27 classes located in various primary schools of Barcelona and is divided into three experimental groups that will be provided with the proposed material (experimental group 1) and additional training and monitoring (experimental group 2) to lastly be compared with the control group which is going to teach the same content without applying the guide. The students' knowledge of the content will be assessed before and after implementation through a pre- and post-test and the behaviours will be recorded through two observation checklists to detect frequency and typology. Teacher's confidence to apply the multisensory approach and their likeliness of future application will be evaluated with Likert-type scale questionnaires; three-phase pilot studies will be conducted to improve their psychometric scale. Two control variables will be implemented, special educational needs and SES, to ensure they will not influence the experimental results. The collected data will be analysed through an analysis of covariance and with the creation of comparative tables that will enable us to understand the instructor's perceptions. The application of the guide is expected to increase 3rd grade teacher's confidence to implement multisensory instruction and to promote its future application. The activities and strategies recommended in the guide are expected to improve students' knowledge and reduce disruptive behaviours in the classroom as all their learning styles have been considered.

Key words: multisensory approach, science, methodology, senses, inclusion

Las metodologías multisensoriales se desarrollaron como una respuesta educativa para los niños en el contexto de las NEE con el fin de estimular varios sentidos simultáneamente apuntando a los puntos fuertes de aprendizaje de cada alumno. El siguiente estudio pretende comprobar si la aplicación de las actividades y estrategias de la guía diseñada, basada en los resultados empíricos, es eficaz en un contexto escolar ordinario mejorando todos los conocimientos y comportamientos de los alumnos y aumentando la confianza y disposición del profesorado para aplicar metodologías más inclusivas y multisensoriales en su aula. La muestra se compone de 27 clases ubicadas en varios colegios de primaria de Barcelona y se divide en tres grupos a los que se les proporcionará el material propuesto (grupo experimental 1) y formación adicional y seguimiento (grupo experimental 2) para finalmente compararlos con el grupo de control que va a enseñar los mismos contenidos sin aplicar la guía. Se evaluará el conocimiento del contenido por parte de los alumnos antes y después de la aplicación mediante un pre y post test y se registrarán los comportamientos mediante dos listas de observación para detectar la frecuencia y la tipología. La confianza y probabilidad de aplicación futura del profesorado se evaluará con cuestionarios de escala Likert, de los que se realizarán estudios piloto en tres fases para mejorar su escala psicométrica. Se aplicarán dos variables de control, NEE y NSE, para garantizar que no influyan en los resultados. Los datos recogidos se analizarán a través de un análisis de covarianza y con tablas comparativas que permitirán comprender las percepciones de los maestros. Se espera que la aplicación de la guía aumente la confianza y voluntad del profesorado para implementar el enfoque multisensorial. También se espera que las actividades y estrategias recomendadas en la guía mejoren el conocimiento de los alumnos y reduzcan los comportamientos disruptivos.

Palabras clave: enfoque multisensorial, ciencia, metodología, sentidos, inclusión

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1. INTRODUCTION

Various studies (Kelly & Phillips, 2016; Rose, 2009; Prashnig, 2008; Spooner, 2011, cited by Boardman, 2020) define **multisensory teaching** as an approach that employs all the senses simultaneously, displaying information through visual, auditory, kinaesthetic, tactile, olfactory and gustatory forms in order to help children learn more effectively.

To understand the connections between the brain and the senses, the key concepts of sensory, sensory integration and multisensory integration must be defined. **Sensory** is the process of detecting stimuli in the environment. Humans have got five sensory systems: the auditory system, the visual, olfactory, gustatory and somatosensory. The neural structures within the somatosensory system involve the perception of temperature, touch, pain and body position (Puspita et al., 2012, cited by Yaswinda, 2017). These are the foundations of Jean Ayres's theory on **sensory integration** (SI), which refers to the capacity of our brain to understand the information coming from the senses and to produce motor and behavioural responses to those stimuli. SI gives us information about what is happening inside and outside the body (Ayres, 1979, cited by Kilroy, 2019). Whilst **multisensory integration** (MI) is the unification of information obtained at the same time from different unisensory channels into a single perception. Deficits in MI have been found in individuals on the autism spectrum disorder and other brain disorders (Cloke et al., 2016; Stein & Stanford, 2008, cited by Marks et al., 2018).

Memory research reveals that multisensory exposure provides superior memory capacity compared to unisensory exposure (Lurii, 1987, cited by Shams & Seitz, 2008), it helps working memory retain information for longer periods (Quack et al., 2015) and it increases attention (Talsma et al., 2010).

Montessori (1912) was one of the first promoters of the multisensory learning movement, which is thoroughly used in her methodology with specific sensory materials designed to be seen, heard, and manipulated. It was in the late 1920s when specialists and researchers started to claim the benefits of multisensory instruction (Saputra, 2015). Grace Fernald also applied that approach, and it is reflected on her book about remedial instruction, published in 1943 (Fernald, 1943). Years later, in the 1970s, Frölich (1982) developed the **basal stimulation** approach to help those with severe disabilities gain a better quality of life. In this method, there are three main areas of intervention: somatic, vestibular and vibratory. Also in the 70s, Hulsegge and Verheul (1987) invented **multisensory environments** (MSEs) which are rooms equipped with items that provide sensory experiences to their users (Fowler, 2008; Lancioni et

al., 2002 cited by Stephenson & Carter, 2011). Nowadays, these particular rooms can be found in many special education institutions as they help children with severe and multiple disabilities develop cognitive and social skills (Gallagher & Balson, 1994, cited by Stephenson & Carter, 2011). Nevertheless, materials on their own are not sufficient for a great intervention, so approaches like **intensive interaction** (Hewett and Nind, 1998) focus on improving students' social communication skills through the interaction between the educator and the educated, which could as well be considered a multisensory practice on its own (Longhorn, 2011).

As shown above, multisensory methodologies originated as an educational response for children in the SEN context (young people with special education needs that affect their capacity to learn) (Spooner, 2011, cited by Boardman, 2020). Dyslexia, for instance, is one learning difficulty which can be better solved through the use of multisensory instruction (Morgan & Klein, 2000, cited by Newman, 2019) as these learners have extra creativity and stronger sensory receptors (Ohene-Djan et al., 2008, cited by Saputra, 2015). The widely used Orton-Gillingham Approach helps dyslexic students improve writing, reading and spelling skills by stimulating their visual, auditory and tactile perceptions (Gillingham & Stillman, 1997, cited by Rosenberg, 2015). That approach also works for mainstream learners as using several senses provides the brain with more connections and associations, so information can be stored and recalled more easily (Cottrell, 2013, Mortimore, 2003, cited by Newman, 2019). Gardner's theory of multiple intelligences (1997) states that all children have their particular strengths and learn in a variety of different ways; therefore, creating an approach that enhances an individual's greater abilities to perceive information provides more opportunities to learn (Flake, 1986, cited by Christensen, 2014).

In recent decades, new technological developments such as virtual reality and serious games have facilitated the use of multiple sensory channels and embodied interaction. That type of **multisensory technology** enables both sighted and blind children to be taught through the same method (Volpe & Gori, 2019). Autistic students struggle with reading comprehension if it is not supported by visual and auditory aids, so more interactive technologies enable them to understand texts better and learn new concepts (De Silva & Dissanayaka, 2018).

The study of Hunter-Carsch in Finland demonstrated that all students benefit when there is an emphasis on multisensory experiences in the classroom, be them physical or digital indistinctly (Hunter-Carsch, 2001, cited by Boardman, 2020). Scientific evidence also suggests that methodologies empowering children's sensory strength can help them stay focused for longer

periods (Ahmad et al., 2008, cited by Saputra, 2015), as it is proven that until the 8 to 10 years of age, sensory modalities interact and mould each other (Volpe & Gori, 2019).

A key factor in understanding the importance of using this approach in non-special education schools is the need to meet diversity. The Catalan Government's decree 150/2017 on educational care aims to promote an inclusive educational system for all students, in all educational stages, until the transition to adult life. To help educators comply with the decree, the Catalan Department of Education has suggested the use of Universal Design for Learning (UDL) framework, to which multisensory instruction can align to (XTEC, 2016).

The uprising call for inclusion was crucial when choosing the topic of this thesis, as the proposed guide aims to help teachers implement a multisensory approach in their classrooms to benefit all their students, including those with learning difficulties or major special needs.

The school curriculum content covered in the guide is a teaching unit about plants within the subject of Natural Sciences. It was chosen as experts in the field of science consider the multisensory approach a great pedagogical method for teaching experimental sciences and nature. It implements all the senses to capture information from the environment around us and organises the information perceived to form complete and meaningful knowledge (Soler, 1999, cited by Rojas & Ubilla, 2014).

Creation objectives

Student centred:

- To create a teaching guide that includes recommendations related to concrete multisensory educational practices, actions and activities that have been proven based on quality empirical studies and that can be applied by educational professionals to significantly **improve student knowledge**.
- To help implement a multisensory methodology into the ordinary class that **improves disruptive behaviours** in particular of learners with special needs.

○ Teacher centred:

- To create a guide that is proven based on quality empirical studies and easy to implement, so 3rd grade **teachers** will **feel confident** to apply multisensory activities and strategies.

-To create a guide that is proven based on quality empirical studies and promotes **the future application of a multisensory approach** within the 3rd grade teachers who have been provided with the guide.

2. MATERIAL

Material design

The material designed for this study is a good practice guide (Appendix A) addressed to teachers from ordinary Catalan schools who want to improve the knowledge and diminish disruptive behaviours of their students by using a multisensory approach. The methodology applied in the guide takes into consideration the diversity found in Catalan schools, focusing on each student's learning difficulties and their preferred learning styles. All the activities suggested appeal to more than one sense and learning style, so that each concept can be understood in multiple ways. That is the reason why the application of the guide is intended to promote inclusive practices.

The elaborated guide is divided in three main blocks. The first one is an introduction of the multisensory teaching approach and its benefits based on empirical data. It includes a short explanation on how our each sense perceives information.

1. What is the multisensory teaching approach?

Multisensory teaching is the approach by which two or more senses are being stimulated at the same time, displaying information through visual, auditory, kinaesthetic, tactile, olfactory and gustatory forms in order to help students learn more effectively (Boardman, 2020). This information will enable us to recognize and understand what is presented to us and will travel to the brain through the nerve endings to process perceptions (Meredith, 2002).

Multisensory methodologies originated as an educational response for children in the SEN context (Boardman, 2020). Yet it has been scientifically proven that they can help all children stay focused for longer periods (Saputra, 2015), provide superior memory capacity compared to unisensory exposure (Shams & Seitz, 2008), help working memory retain information for longer periods (Quack et al., 2015) and increases attention (Talsma et al., 2010).

1.1. Senses involved:



Hearing: Hair cells are the sensory receptors of the auditory system and the vestibular system in the ears. The cells move in response to specific sounds. Ears can pick up kinaesthetic, postural, and balance stimuli.

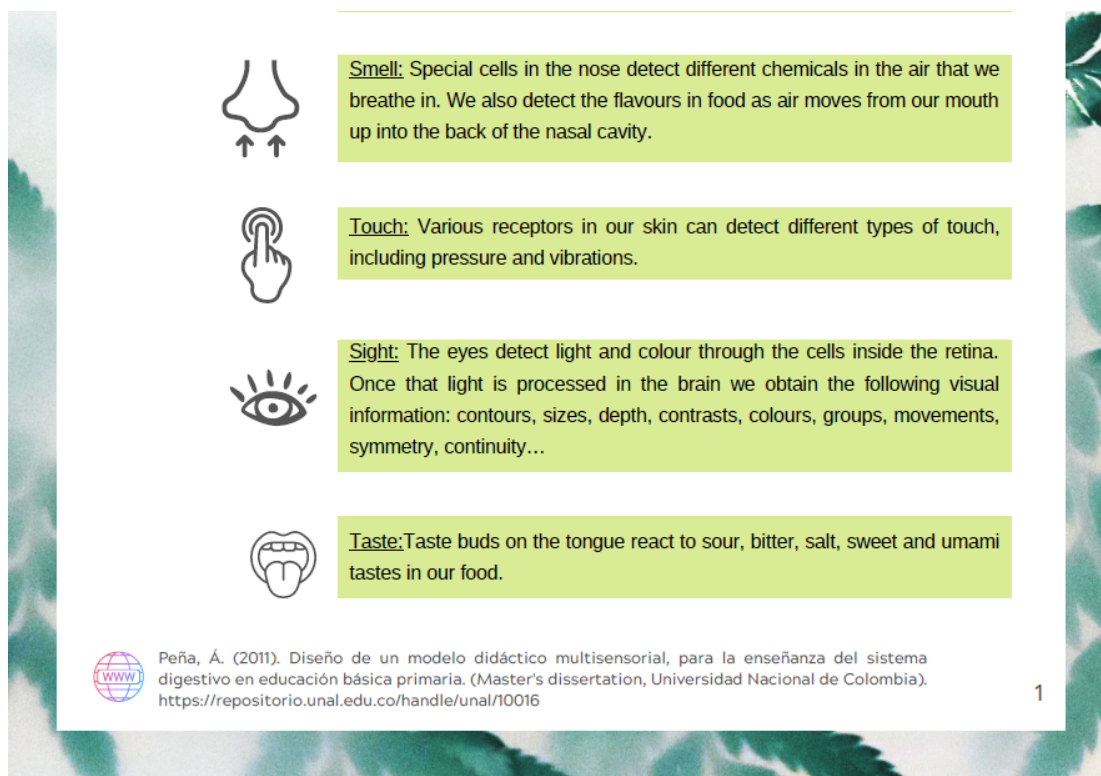


Figure 1. Introductory page of the guide (see Annex 1 for the complete guide).

The second part consists of examples of different materials and activities that are used in educational settings to help students learn stimulating different senses at the same time. Most of them are used as compensation strategies for learners with difficulties, yet they could be used for the whole class.

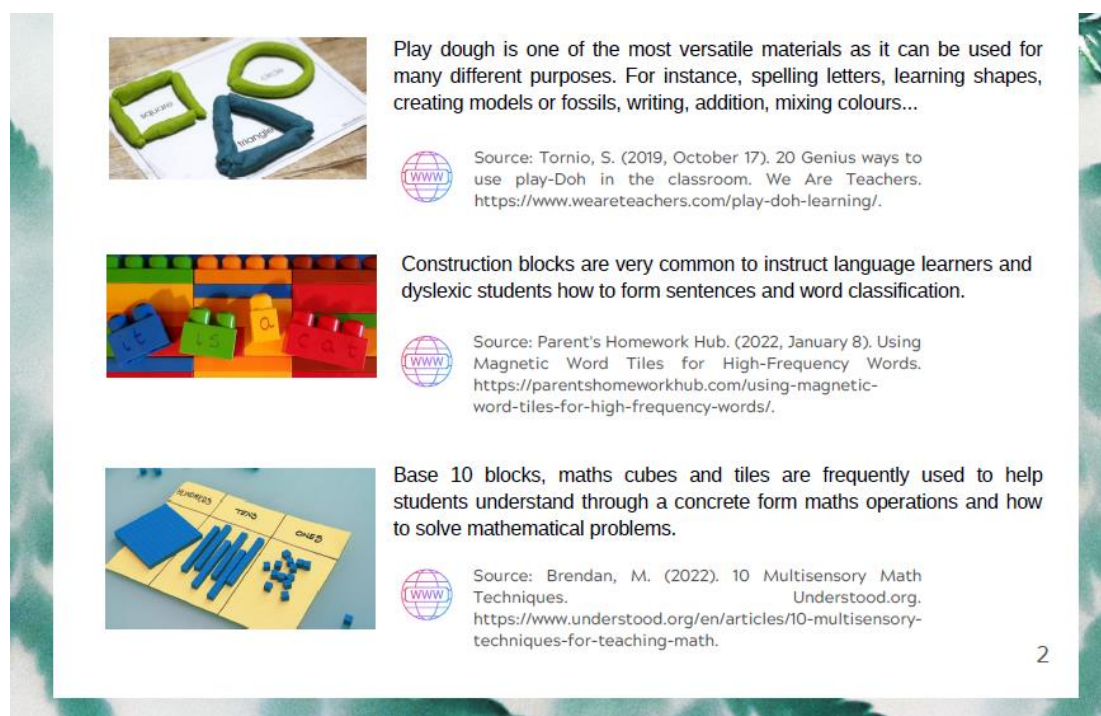
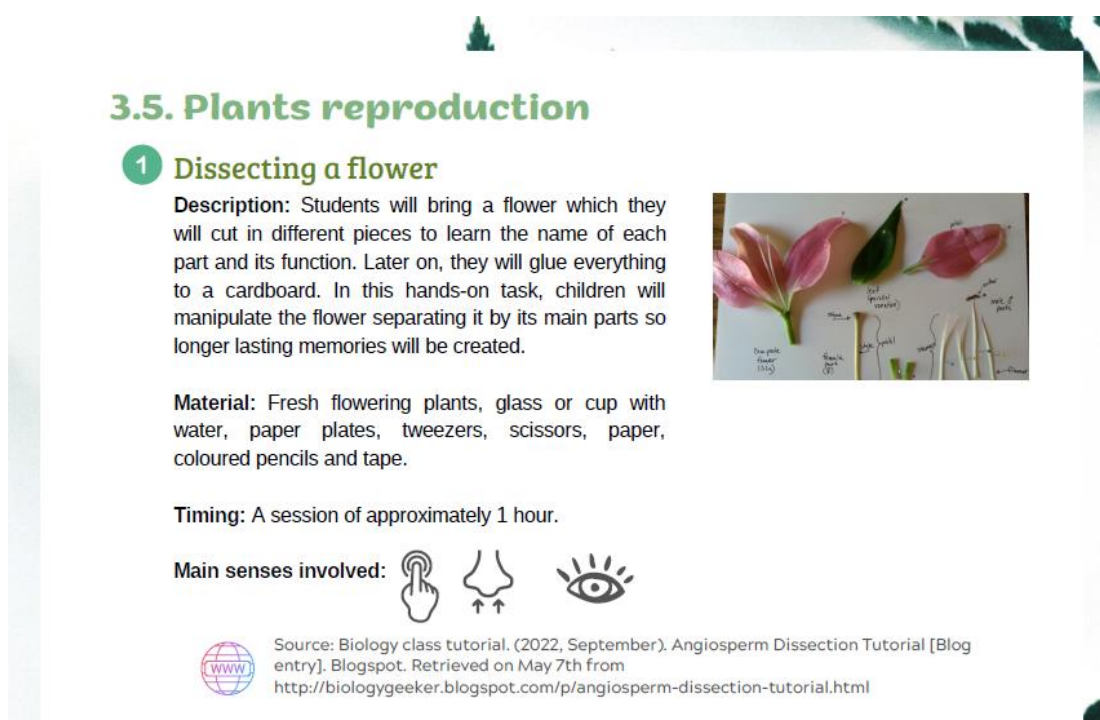


Figure 2. Examples of application page 1 (see Annex 1 for the complete guide).

The third part of the guide is the teaching unit about plants, which is annually taught in Catalan primary schools to 3rd grade students. All the activities and materials have been developed based on empirical data which is registered on a table below. They are shown in order from less to more difficult, taking into account the main steps of a learning unit: introduction, development and the evaluation. The last will be a final test, the same one used before starting the unit to observe the previous knowledge, both utilised as data collection instruments. The titles of the activities indicate the content to be taught and the material or activities involved.

The content topics covered are: characteristics of plants, plant cells, types of plants, how to use a dichotomous key to classify plants, the life cycle of plants, plant nutrition, photosynthesis, plant reproduction, parts of a flower, flower reproduction and pollination.

Those contents were extracted from the primary school curriculum of Catalonia's Department of Education.



3.5. Plants reproduction

1 Dissecting a flower

Description: Students will bring a flower which they will cut in different pieces to learn the name of each part and its function. Later on, they will glue everything to a cardboard. In this hands-on task, children will manipulate the flower separating it by its main parts so longer lasting memories will be created.

Material: Fresh flowering plants, glass or cup with water, paper plates, tweezers, scissors, paper, coloured pencils and tape.

Timing: A session of approximately 1 hour.

Main senses involved: 



Figure 3. Activity proposal to be implemented (see Annex 1 for the complete guide).

The following table is an extract of the contents that must be covered in 3rd grade regarding the topic of plants as they are stated in the official curriculum.

Specific contents of the area of knowledge of the natural environment
Contents of the area of knowledge of the natural environment middle cycle (3rd and 4th)

The world of living things • Characterization of the function of nutrition in animals and plants. • Characterization of the function of reproduction from the observation of animals and plants. • Characterization of the relationship function based on the observation of animals and plants and relating them to their habitats. • Classification of the different groups of animals and plants in the immediate environment. Use of simple dichotomous keys. • Interest in the observation, care and protection of animals and plants in the immediate environment, and prevention of possible risks.
Mid-cycle evaluation criteria (3rd and 4th)
2. Classify animals and plants in the immediate environment and recognize basic characteristics according to scientific criteria.

Table 1. Curriculum content. Natural Science. 3rd and 4th Grade. Source: Servei d'Ocupació Curricular, 2017.

The activities suggested on the guide to instruct the target content were based on quality empirical articles of different authors that conducted research on multisensory learning.

Material or Activity	Theoretical foundation
Real objects	Real objects which are available in the environment such as toys, maps, menus, nature objects, etc. Are more efficient to learn new vocabulary as children memorise them more effectively than they do by looking at pictures that represent them (Bara & Kaminski, 2019).
Manipulative materials	Objects that a student can feel, touch and handle. They serve as learning tools and evocate different senses at the same time. Learners can work directly with them or mentally (Reys, 1971, Sowell, 1989 cited by Rains et al., 2008). Teachers must consider how the object to be used relates to the target concept, what can be done with it and how, in order to promote understanding (Macrine & Fugate, 2021).
Hands-on science activities	They are science activities that enable students to manipulate handle and observe scientific processes. They increase learner's curiosity and can make them develop more elaborated ideas about scientific practices (Lumpe and Steven, 1991; Holstermann et al., 2010; Hofstein & Lunetta, 2003, cited by Nagy et al., 2022).
Taking notes	Handwriting helps students re-evaluate and assimilate their notes thanks to the slowness of the process. It requires more attention and improves memory, reading and language skills (Macrine & Fugate, 2021).

Play Dough	This mouldable material enables students to develop their fine motor skills, helps them begin using symbolic thinking, involves practicing science and maths skills, plus it can be transformed into any relevant content we wish to teach (Michigan State University, 2022).
Letter manipulatives	This manipulative version of letters allows students to feel and see different perspectives of their shape providing them with a strong literacy foundation. They are used as well to build words (Shams & Seitz, 2008).
Working outside the classroom	Conducting lessons outside the classroom, especially in nature rich environments; increases children's attention, encourages physical activity and builds a sense of competence and collaboration (Jacobi-Vessels, 2013).
Images, video, simulations and diagrams	There are several formats to display big amounts of information which help reveal relationships and patterns: images, videos, simulations or diagrams. Visual learning can help develop visual thinking that makes learners retain information more easily by associating ideas, words and concepts with images (Raiyn, 2016).
Augmented reality (AR)/ virtual reality (VR) technologies	They allow students to learn through movement, increase their interest and result in more accurate performance (Macrine & Fugate, 2021).
Visual representation strategy (for words)	This strategy connects words to visual representations. It is used to teach sight words by connecting them to a drawing made by the student or by looking at the word written and playing to memorise it for some seconds and then write it (Mills, 2018).
Books	Printed books involve the kinaesthetic and tactile sense as well as sight, which can improve comprehension (Macrine & Fugate, 2021).
Transmedia storytelling	A story experience that unfolds through multiple platforms and formats. It combines online, and offline experiences and it has been demonstrated to increase engagement and improve knowledge acquisition (Jenkins, 2008; Raybourn, 2014; Fleming, 2013, cited by Nagy et al., 2022).
Acting-pantomime	Acting out vocabulary, sentences, text or processes through gestures and pantomime improves comprehension and memory (Macrine & Fugate, 2021).
Smelling	Olfaction is strongly connected with emotions and can affect behavior. The olfactory network provides the neural basis for the strong link between olfactory stimuli and emotional memory, so this sense helps retain memories (Ponticorvo et al., 2019).
Visiting nature	The smell-breath-life association helps individuals be more aware of the vital when they connect with the fragrant world on a natural space and that for; they foster longer lasting memories (Sánchez-Osorio, 2017).
Smelling jars	Jars filled with different scents and students must identify them and match each

	with the real fruit, flower or plant (Montessori, 1917). The display must reinforce the difference between smells (Kaye, 2001, cited by Klašnja-Milićević et al., 2019).
A basket of elements	A free exploration activity to smell and touch the items that will be later on studied. It can boost the interest of students and anticipate the topic (Montessori, 1917).
Flavour jars	Bottles filled with different tastes coming from plants are placed in a tray for students to identify and match (Montessori, 1917).
Using sounds to describe tastes	The association of flavours with musical tones helps identify them (Pring et al., 2005, cited by Sánchez-Osorio, 2017).
Phonological relationship strategy	It is a strategy used to instruct dyslexic students the connection between pronunciation and spelling. The arm or the fingers are used to tap out the sounds of letters, separate syllables and understand word blends (Mills, 2018).
Music and movement	Musical learning and rhythmic games help improve the level of self-awareness and favor the expression of feelings and self-esteem (García, 2004, cited by Sánchez-Osorio, 2017).
Gestures	Gestures can help to convey ideas, understand vocabulary and to capture dynamical sense of a concept (Macrine & Fugate, 2021).
Total body response	Total Physical Response (TPR) is a language teaching method that synchronizes language and physical movement. It can be used to teach vocabulary by reacting to verbal inputs with actions (Rompas, N. & Recard, M., 2021).

Table 2. Elements from the designed teaching guide and their theoretical foundations.

3. METHODOLOGY

Sample participants

The following study is designed to increment learning and to improve the behaviour of all students through the application of a multisensory teaching approach that is inclusive and takes into account students with special needs and learning difficulties. Therefore, participants will come from 27 different schools organised in 3 different categories: high complexity, public and semi-private schools. Within the three main groups the schools will be divided by the percentage of migrants or non-native speakers studying in them and by the social economic status of their pupils. The specific features of the sample and the schools that will act as study participants can be found in Table 3.

	Control group	Experimental group 1	Experimental group 2
High complexity school 0-30% of migrants or non-native speakers	Escola C.B.	Escola M. B.	Escola T.
High complexity school 30-60% of migrants or non-native speakers	Escola M.	Escola A. G.	Escola B. de V.
High complexity school 60-100% of migrants or non-native speakers	Escola P.	Escola M. i F.	Escola A.
High social economic status public schools	Escola P. F.	Escola N.	Escola T.
Middle social economic status public schools	Escola la S.	Escola T.	Escola Í.
Low social economic status public schools	Escola D.	Escola M. i F.	Escola M.
High social economic status semi-public schools	Escola A.O.L	Col·legi M.	Escola S. C.-S.
Middle social economic status semi-public schools	Escola V.-G.	Escola N. P.	Escola V.
Low social economic status semi-public schools	Escola C. de M. S.	Escola A.	Escola S.F. N.

Table 3. Sample schools that will participate on the study.

The variables to be studied will be the improvement of student knowledge; the decrease of disruptive behaviours in the classroom context; teacher confidence in applying a multisensory approach themselves and teacher perception of likeliness of future application on their own.

In order to obtain valid results, we will **exclude from the sample** students who have not been over 5 years living in Spain. Thus, we will ensure that results are not influenced by language comprehension problems.

To measure the effectiveness of the designed material, an experimental quantitative research will be carried out, through a pre- and post-test, measuring the degree of knowledge demonstrated by students before and after the application of the strategies and activities found in the document and also an observation list to be filled by teachers regarding the behaviour of most disruptive students and those with special needs. The results obtained in the experimental groups will be separated into those of students with special needs and those without in order to determine the inclusivity of the guide through further research.

To ensure the teacher objectives are being met, two questionnaires will be filled by the ones involved

in experimental groups 1 and 2. One will check their confidence in applying a multisensory approach and lastly the teacher’s perception of likeliness of future application of multisensory lessons on their own. The surveys will be piloted with the intention of generating a validated instrument. The chart below demonstrates the timing and steps of the process to generate them.

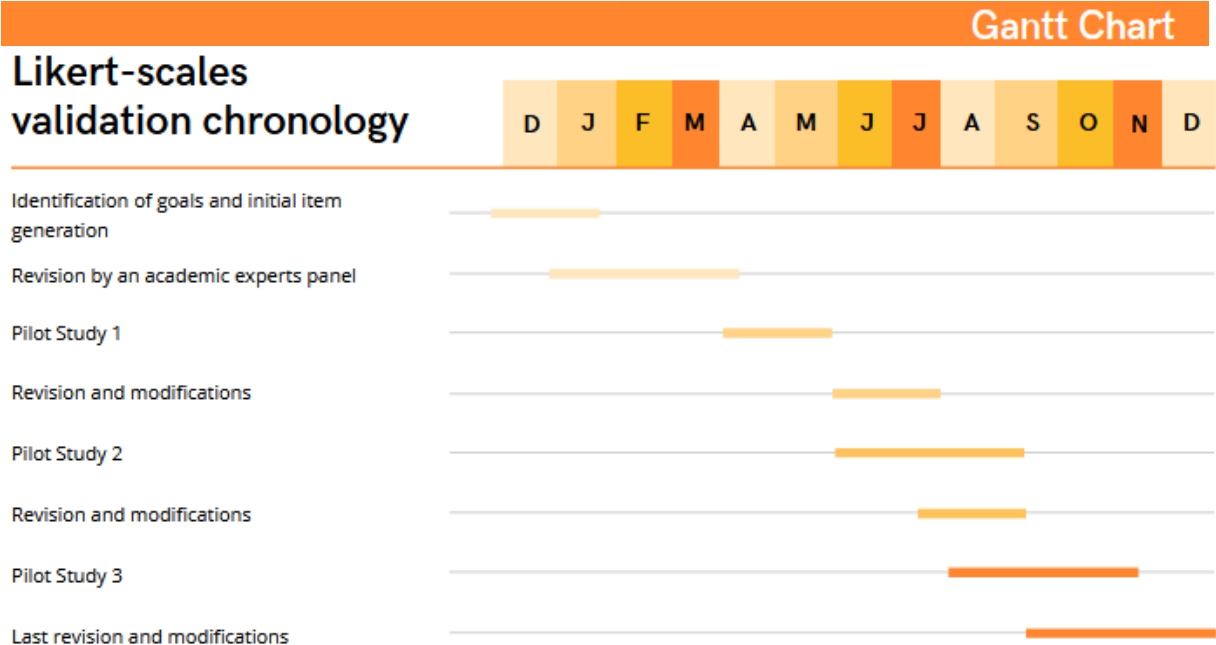


Table 4. Gantt chart representing the expected timeline of the Instruments Pilot study.

The following table shows the proposed implementation of the study scheduled through an academic year and one year in advance in the case of the instrument’s pilot study.

		ACADEMIC YEAR											
STUDY PHASE		December (1year in advance)	S	O	N	D	J	F	M	A	M	J	S (After summer)
Instruments’ pilot study													
Study design													
Initial evaluation (pre-test)													
Experi- ment	Guide Distribution and training												
	Implementation												

	Follow-up												
Final evaluation (post-test)													
Final evaluation 2 (post-test)													

Table 5. Complete study timeline.

The study design will take place in December and January. The following month teachers will be expected to fill in the close answer questionnaires, to initiate the completion of the observation lists and to ensure that all students take their tests about plants to determine their level of previous knowledge. When everything has been filled, the guide will be distributed and teachers will have some time to prepare the activities, ask questions and plan their lessons. It will be spring during the months of the implementation, this has been decided on purpose as the teaching unit is about plants and some activities require the observation and collection of flowers, so it is important for the correct implementation that they have bloomed. During the whole implementation, which is supposed to last around two months, teachers from the experimental group 2 will receive a continuous follow-up and an in-depth training. Once the teaching unit has been completed, all the data collection instruments will be filled again in order to proceed with the study analysis. In the case of the plants test, it will be taken again in September after the summer holidays to analyse the impact of multisensory instruction in long-term memory.

Each school organizes the timetable differently, and they don't have the same amount of hours of social sciences per week, so the implementation period will be slightly different within the sample.

Independent variables

The application of the strategies and multisensory lessons developed in the guide will become the independent variable of this fictitious study. In order to observe and analyse its impact, there will be two experimental groups and one control group, the latest won't have access to the teaching guide, yet they will be taught in a different manner the same topic and their results will be measured in order to compare them with the experimental groups. The first experimental group will be provided with the teaching guide and a brief initial training. Differently, the second experimental group will enjoy an in-depth training with a follow-up through the course. In addition, since it is a teaching material, the participating teachers will be asked for their confidence to apply the approach and the future possibility of implementation.

Dependent variables

Five dependent variables will be measured: student knowledge, the presence of disruptive behaviours in the classroom context, teacher confidence in applying the approach with and without the guide and teacher perception of likeliness of future application on their own. In order to measure the three dependent variables mentioned above and also check if the application of the designed teaching guide leads to improvements, a pre-test and a post-test will be performed using the data collection instruments explained below.

Student knowledge test. A pre-test and a post-test will be designed to assess knowledge of students about the chosen topic from the 3rd grade curriculum: plants. The same test (Annex 2) will be realized by all students individually right before they start the teaching unit, to check their previous knowledge, and by the end of it to check what they have learnt and retained. The comparison of those two results will indicate their level of acquisition of the new concepts, and it will enable a further study on the contrast between control group results and experimental group results.

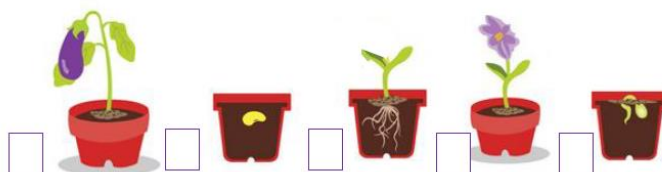
Name:	3 rd Grade	Date:
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Plants test

1. What happens when we **uproot** plants? Can they grow again?

2. Put in order (1 to 5) the steps involved in the **plant cycle** and match them with the corresponding picture.

- ____ Stems grow pushing up towards the light and roots grow down into the soil.
- ____ Photosynthesis. Leaves unfold and take in sunlight to produce food while flowers bloom.
- ____ Pollination, in this step seeds and fruits are produced.
- ____ The seed. Seeds hold inside a tiny plant and a food supply protected by a seed coat.
- ____ Germination. The plant becomes a sprout and begins to grow thanks to water, soil and sun.



3. Name the following **types of plants**:



4. Name all the **parts of a plant** and give one example of an **eatable** plant for each part.
For example: sunflower seeds.

Figure 4. Plant knowledge test for 3rd grade students based on the Catalan Primary School Curriculum (See complete test in Annex 2).

Disruptive behaviours within the classroom context. The following variable will be measured through observation by completing two control lists exactly as they are exposed in the project proposal of Arrufat (2021) which will provide quantitative and qualitative data. The timing for the data collection was amended to suit the needs of this study in particular.

The first control list must be filled by the teacher periodically from the start of the teaching unit proposed on the guide until the end of it. This instrument is based on Leff's et al. study (2011) and focuses on the frequency, absence or presence of disruptive behaviours in the classroom context. The second list will be completed by the teacher once a disruptive behaviour arises in order to collect qualitative data about the frequency and most common negative behaviours that interfere learning.

The negative conducts to be considered are extracted from high quality empirical studies and amended by Arrufat's proposed study (2021). The control list includes the following disruptive behaviours: (a) shouting (b) spitting (c) hitting (d) teasing (e) waiting more than five minutes to comply with teacher regulations (f) taking material from a classmate without permission (g) interrupting the explanation of the teacher (h) talking off duty (i) disobeying the teacher's instructions (j) interrupting classmates' work (k) getting up from the chair without permission (l) making annoying noises to disrupt the development of the class (m) confronting the teacher (n) insulting (o) threatening (p) getting angry (q) damaging classmates and school supplies (r) throwing objects in the air and lastly (s) leaving the classroom without permission (Stormont et al., 2007; Clunies-Ross et al., 2008; Simon et al., 2013, cited by Arrufat, 2021).

The results obtained through observation will be registered in the above mentioned instruments in order to be analysed.

Disruptive Behaviours	Frequency observed							
	1	2	3	4	5	6	7	8
Shouting								
Spitting								
Hitting								
Teasing								
Waiting more than five minutes to comply with teacher regulations								
Taking material from a classmate without permission								
Interrupting the explanation of the teacher								
Talking off duty								
Disobeying the teacher's instructions								
Interrupting classmates' work								
Getting up from the chair without permission								
Making annoying noises to disrupt the development of the class								
Confronting the teacher								
Insulting								
Threatening								
Getting angry								
Damaging classmates and school supplies								
Throwing objects in the air and lastly								
Leaving the classroom without permission								

Table 6. Frequency of disruptive behaviours observation list.

Teacher confidence in applying. To measure teacher's confidence in applying the activities and strategies suggested in the guide an instrument will be developed, revised by a panel of academic experts and a three-phase pilot study will be conducted to improve its psychometric scale properties following the steps and analysis used in Wilson-Daily et al. instrument development article (2021b). The following table displays the first instrument generated which would be adapted once the pilot study is conducted. It contains a 5-point Likert-type scale, the structure of the questions is amended from Montánchez's study on inclusivity (2014) and the content is based on

Boardman's empirical article on the multisensory approach, its benefits and implementation (2020). There are two dimensions that have been checked in the survey: (1) Opinion on multisensory approach utility and of key benefits and (2) Self-evaluation of ability to incorporate the approach in their classroom.

Participants will be asked to read statements about their perception, and ability to apply a multisensory approach and they will have to rate the degree to which they agree or disagree with these statements (1=strongly disagree to 5=strongly agree). The items will be (a) "The multisensory method uses different senses at the same time to help students memorize more effectively" (b) "Multisensory learning can be beneficial for all students" (c) "Students with or without special educational needs; they should have the same curriculum in the classroom" (d) "I believe that multisensory learning should be used in all subjects" (e) "To be a good teacher and of quality it is necessary to know how to adapt the working methods to the characteristics and needs of the students" (f) "I consider myself sufficiently trained to apply multisensory learning" (g) "I have strategies and skills to work in a multisensory way in the classroom" (h) "I develop lesson plans that take into account students with special educational needs" (i) "I try to create materials that can help all my students learn" (j) "As a teacher, I adapt the learning contents of the students" (k) "In my classroom I take into account the different learning rhythms of the students"

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<u>Opinion on multisensory approach utility and of key benefits</u>					
The multisensory method uses different senses at the same time to help students memorize more effectively					
Multisensory learning can be beneficial for all students					
Students with or without special educational needs; they should have the same curriculum in the classroom					
I believe that multisensory learning should be used in all subjects					
To be a good teacher and of quality it is necessary to know how to adapt the working methods to the characteristics and needs of the students					
<u>Self-evaluation of ability to incorporate the approach in their</u>					

<u>classroom</u>					
I consider myself sufficiently trained to apply multisensory learning					
I have strategies and skills to work in a multisensory way in the classroom					
I develop lesson plans that take into account students with special educational needs					
I try to create materials that can help all my students learn					
As a teacher, I adapt the learning contents of the students					
In my classroom I take into account the different learning rhythms of the students					

Table 7. Likert scale questionnaire to assess confidence in applying.

Teacher perception of likeliness of future application on their own. To measure this variable another pilot study will be conducted using the same methodology as with the one mentioned above in order to refine the survey questions and generate a rigorous data collection instrument. In this case, a 5-point Likert-type scale will be created amending Montánchez's study questionnaire (2014). There is only one dimension: (1) Likelihood of future application.

Participants will be asked to read statements regarding their future and to rate the degree to which they will likely or unlikely act towards these statements (1=very unlikely to 5=very likely). The items will be (a) "I am willing to rethink the use of multisensory methodology in my educational work" (b) "I am willing to elaborate materials that involve more than one sense simultaneously" (c) "I am willing to learn what I should do as a teacher in the classroom to address each student's learning styles" (d) "I am willing to learn what I should do as a teacher in the classroom to address each student's learning difficulties and special needs" (e) "I am willing to apply a multisensory approach in the classroom".

	Very unlikely	Unlikely	Neutral	Likely	Very likely
<u>Likelihood of future application</u>					
I am willing to rethink the use of a multisensory approach in my educational work					

I am willing to elaborate materials that involve more than one sense simultaneously					
I am willing to learn what I should do as a teacher in the classroom to address each student's learning styles					
I am willing to learn what I should do as a teacher in the classroom to address each student's learning difficulties and special needs					
I am willing to apply a multisensory approach in the classroom					

Table 8. Likert scale questionnaire to assess likelihood of future application.

Control variables

This study will include one control variable related to the student's special educational needs. The aim is to study if there is any correlation or significant difference between the improvement in knowledge and disruptive behaviours of those with special needs and without.

Special education needs. The necessary information to study the influence of this variable on the final results will be extracted from a self-elaborated questionnaire in which teachers will state the diagnosis and learning difficulties of the students from their class who have special educational needs.

Students with special educational needs	
Name of the student:	
Diagnosis:	
Learning difficulties derived from their special needs:	

SES. To study this particular variable, the indicator developed by Wilson-Daily and Kemmelmeier (2021a) will be used with the following changes: "the amount of books at home" will not be taken into account and will be replaced by "the amount of digital platforms used at home". Two other items will be added: "if participants are enrolled in extracurricular activities" and "frequency of attendance to cultural events".

To check if the first control variable has had an influence on the results, a regression analysis will be done after the pre-test and post-test results of the student objective variables had been studied. For the second control variable factor analysis will be used to determine the correlation.

Study objectives

○ Student centred:

-To determine if significant differences exist between the control groups 1 (whose teacher will not be using the activities and suggestions from the guide and that for avoiding the multisensory approach), group 2 (whose teacher will have used the guide proposals) and group 3 (that will have used the guide, some training and school visits to ensure the correct implementation) regarding the **student knowledge**.

-To determine if significant differences exist between the control groups 1, 2 and 3 regarding the **level of improvement of student behaviour** in particular of learners with special needs.

○ Teacher centred:

-To verify, through the measurement of variables using a post-test, if the 3rd grade teachers from the control groups 2 and 3 which implemented the guide **feel significantly more confident in their ability to apply multisensory activities and strategies** after following the guide.

-To verify, through the measurement of variables using a post-test, what is the 3rd grade teacher's **perception of likeliness of future application** of the multisensory approach on their own.

Data collection

The evaluation of the sample will be done before and after the implementation of the guide like it is scheduled in the "*participants*" section described above. The data collection will provide information of the three groups (control 1, experimental 1 and experimental 2) using the instruments detailed in the "*variables*" sections. All instruments will be administered in Catalan as it is the vehicular language in the sample schools.

The quantitative and qualitative information obtained will be analysed in order to corroborate the hypothesis.

Data analysis

In order to analyse the data collected, we will use an ANCOVA (Analysis of Covariance) as it would allow the comparison of multiple time-points within each sample group and the experimental groups against the control one. ANCOVA would be the most suitable method to test our hypothesis as covariates can be added freely to the analysis as it is explained in Dugard & Todman's (1995) article. Specifically, we will analyse the difference between the pre- and post-tests, compare it to the control group results and contrast the improvement in knowledge and behaviour of students with special education needs with those in their classes whose teachers didn't specify any special need or learning difficulty.

The data obtained through the surveys will be analysed with the creation of comparative tables that will enable us to understand the teacher's perceptions.

Hypotheses

The hypothesis of this study will be based on Kumar's Research Methodology (2011). There will be two hypotheses formulated for each objective proposed. The first one is a null hypothesis which indicates that there would be no difference between the sample groups when implementing the guide and the second one, is a difference hypothesis that specifies if there would be some differences, but the magnitude is not detailed.

Student objectives

Hypothesis of student objective 1:

H1₀: The implementation of the guide's concrete multisensory educational practices, actions and activities does not contribute to significant improvements in student knowledge.

H1: The implementation of the guide's concrete multisensory educational practices, actions and activities provides a significant improvement in student knowledge.

Hypothesis of student objective 2:

H2₀: The implementation of a multisensory methodology into the ordinary class does not contribute to a significant reduction of disruptive behaviours of learners with or without special needs.

H2: The implementation of a multisensory methodology into the ordinary class provides a significant reduction of disruptive behaviours of learners with or without special needs.

Hypothesis of teacher objective 1:

H1₀: The created guide that is proven based on quality empirical studies and easy to implement does not contribute to a significant feeling of confidence in teachers towards its application.

H1: The created guide that is proven based on quality empirical studies and easy to implement provides a significant feeling of confidence in teachers towards its application.

Hypothesis of teacher objective 2:

H2₀: The created guide that is proven based on quality empirical studies does not contribute to a significant promotion of the future application of the multisensory approach within the teachers who have implemented it.

H2: The created guide that is proven based on quality empirical studies provides a significant promotion of the future application of the multisensory approach within the teachers who have implemented it.

Limitations

The study pretends to prove the benefits of the multisensory approach through its application in various Catalan schools. However, despite the many dependent and control variables that will be utilised to conduct the study, there are some limitations to it.

To determine the improvement of student's knowledge, marks, the social-economic status and their special educational needs have been considered. Nevertheless, the knowledge demonstrated in the post-test may not be retained for a long period of time as memories that are not accessed frequently can easily be forgotten or become harder to recall (Camina & Güell, 2017). It would be interesting to re-test students after some months to analyse if their learning has been permanent and stored as long-term memory in their brains. Scientific data from Shams & Seitz (2008) article states that multisensory exposure provides higher memory

capacities compared to unisensory and allows working memory keep the information for a longer time (Quack et al., 2015), so a third test would allow to confirm these findings.

The diminished frequency of disruptive behaviours has also been considered part of the possible benefits of the approach, but the classroom climate or the emotional problems that some children may be experiencing could as well influence the results.

Teacher's perceptions and confidence are subjective, and they could be influenced by their previous work experience, preferred teaching methodologies, their well-being and attitude towards new approaches and newness.

Regarding the material created, multisensory instruction can be used in all school subjects and focusing only on one content topic has narrowed the proposal of activities that can be found in the guide designed. Although if the results of this study were successful, a larger one that embraces all the curriculum subjects could be conducted.

The application of the guide could be limited by the possibilities of the school to acquire the necessary material, yet it could be provided and funded by the entity in charge of the research.

The last limitation to be considered is teacher compliance as the results are completely dependent on their ability and willingness to implement the activities and strategies suggested in the guide.

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Figure 5. Independent Living. (2022). Life Cycle of a Green Bean Plant [Digital image]. Retrieved 10 May 2022, from <https://www.independent-living.shop/en/product/lifecycle-bean/>

Figure 6. MagicStonesArtShop . (2022). Ciclo de vida de la abeja melífera materiales Montessori [Digital image]. Etsy. (2022). Retrieved 4 June 2022, from <https://www.etsy.com/es/listing/858527040/ciclo-de-vida-de-la-abeja-melifera>

ANNEX 1. MATERIAL CREATED

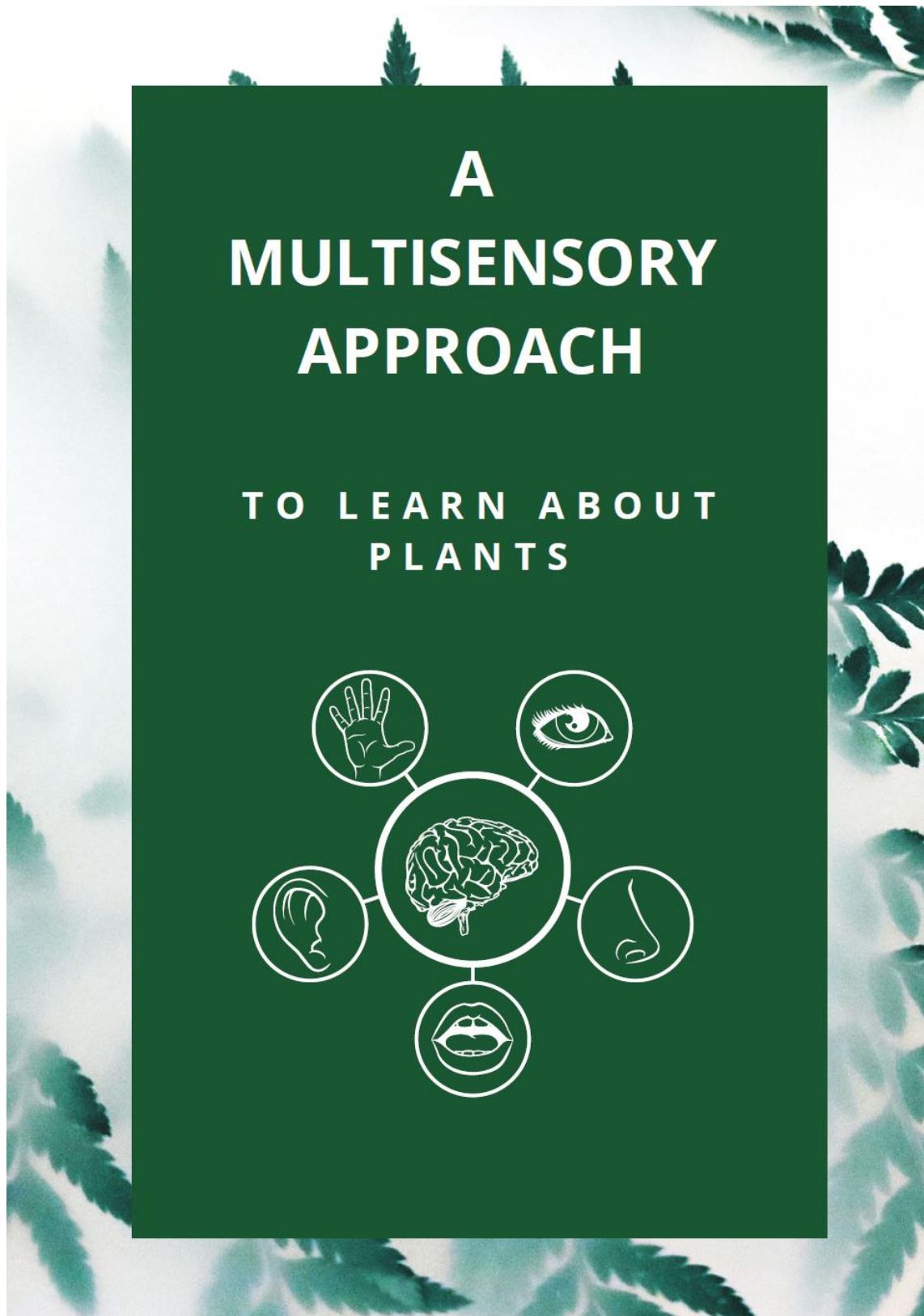


Figure 5. Guide cover.

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1. What is the multisensory teaching approach?

Multisensory teaching is the approach by which two or more senses are being stimulated at the same time, displaying information through visual, auditory, kinaesthetic, tactile, olfactory and gustatory forms in order to help students learn more effectively (Boardman, 2020). This information will enable us to recognize and understand what is presented to us and will travel to the brain through the nerve endings to process perceptions (Meredith, 2002).

Multisensory methodologies originated as an educational response for children in the SEN context (Boardman, 2020). Yet it has been scientifically proven that they can help all children stay focused for longer periods (Saputra, 2015), provide superior memory capacity compared to unisensory exposure (Shams & Seitz, 2008), help working memory retain information for longer periods (Quack et al., 2015) and increases attention (Talsma et al., 2010).

1.1. Senses involved:



Hearing: Hair cells are the sensory receptors of the auditory system and the vestibular system in the ears. The cells move in response to specific sounds. Ears can pick up kinaesthetic, postural, and balance stimuli.



Smell: Special cells in the nose detect different chemicals in the air that we breathe in. We also detect the flavours in food as air moves from our mouth up into the back of the nasal cavity.



Touch: Various receptors in our skin can detect different types of touch, including pressure and vibrations.



Sight: The eyes detect light and colour through the cells inside the retina. Once that light is processed in the brain we obtain the following visual information: contours, sizes, depth, contrasts, colours, groups, movements, symmetry, continuity...



Taste: Taste buds on the tongue react to sour, bitter, salt, sweet and umami tastes in our food.



Peña, Á. (2011). Diseño de un modelo didáctico multisensorial, para la enseñanza del sistema digestivo en educación básica primaria. (Master's dissertation, Universidad Nacional de Colombia). <https://repositorio.unal.edu.co/handle/unal/10016>

Figure 7. Guide introductory page.

2. Examples of application



Sand trays are used to learn letter sounds and practice letter formation. This resource was developed by the Montessori and Orton-Gilligham methodologies.



Source: PRIDE Reading Program. (2021, February 17). Top 5 Multisensory Writing Activities [Video]. Youtube. <https://www.youtube.com/watch?v=skFIGOYGSj8>



Moving beads on a string while saying the different syllables and counting them is another activity from the Orton-Gilligham approach to help improve pronunciation and reading skills.



Source: RIDE Reading Program. (2020, December 1). My Favorite Multisyllabic Word Activities [Video]. Retrieved 1 June 2022, from Youtube. <https://www.youtube.com/watch?v=uFEsFsqaajw>



Pipe cleaners on pencils are used to demonstrate the power of Silent-e which doesn't sound, but makes the previous vowel say its name.



Source: Brainspring. (2019, April 4). Orton-Gillingham lesson basics: Multisensory Introduction. <https://brainspring.com/ortongillinghamweekly/orton-gillingham-lesson-basics-multisensory-introduction/>



Play dough is one of the most versatile materials as it can be used for many different purposes. For instance, spelling letters, learning shapes, creating models or fossils, writing, addition, mixing colours...



Source: Tornio, S. (2019, October 17). 20 Genius ways to use play-Doh in the classroom. We Are Teachers. <https://www.weareteachers.com/play-doh-learning/>



Construction blocks are very common to instruct language learners and dyslexic students how to form sentences and word classification.



Source: Parent's Homework Hub. (2022, January 8). Using Magnetic Word Tiles for High-Frequency Words. <https://parentshomeworkhub.com/using-magnetic-word-tiles-for-high-frequency-words/>



Base 10 blocks, maths cubes and tiles are frequently used to help students understand through a concrete form maths operations and how to solve mathematical problems.



Source: Brendan, M. (2022). 10 Multisensory Math Techniques. Understood.org. <https://www.understood.org/en/articles/10-multisensory-techniques-for-teaching-math>

Figure 8. Second part of the guide-examples of application.

3. Plants teaching unit through a multisensory approach:

3.1. Introduction: Characteristics of plants

1 Nature observation - Taking notes and drawing

Description: This activity consists of visiting the school's playground or a park to observe all the plants that surround them. There students will take notes and draw in groups what they observe (types of plants, shapes colours...) and will collect some samples of bark, flowers, or leaves to bring to the class for further investigation.

To make sure students write down relevant content we can provide them with a table that has the following titles:

Name - Type of plant - Size - Characteristics - Drawing

Material: Pencils, papers notebooks, and bags.

Timing: A session of approximately 1 hour.

Main senses involved:



2 Deeper observation - Exploration trays

Description: This observation exercise will enable students to have a closer look inside and outside plants and is inspired by Montessori exploration trays (1917).

To prepare the task, add a variety of leaves, flowers and bark inside a tray to let students observe them through magnifying glasses and placing them under a microscope or to experiment by cutting, touching and smelling them. Using a digital microscope would allow all students to see the inside of a plant through a bigger screen and would serve as an introduction to learn about plant cells.

Material: Trays, a digital microscope, a digital board or computer, magnifying glasses, scissors and a mix of real flowers and leaves.

Timing: A session of approximately 1 hour.

Senses involved:



Source: Jennie (2018, May 11). Spring Sensory Play: Flower Cutting Tray [Blog entry]. WordPress. Retrieved on May 3rd, from http://www.edspire.co.uk/year_2018/05/11/spring-sensory-play-flower-cutting-tray/.

Figure 9. Third part of the guide-activities taught through multisensory approach.

3 Plant cell - Video, diagram & building a plasticine model

Description: To understand what plants are made of and to distinguish the parts of a cell, this activity has been divided in three main tasks.

Task 1: Students will watch a 3D animated video that shows and names the inside of a plant cell <https://www.youtube.com/watch?v=xGEoK8kRNoQ>. This will stimulate students sight and hearing senses.

Task 2: A big diagram without names will be shown to students and they will have to place the name tags in the correct area. This can be done first as a big group to foster kinaesthetic learning, later in smaller groups and to end we will ask students to draw and copy the names of the diagram on a paper.

Task 3: Students will be asked to create in groups a model of a plant cell using scented Play Dough stimulating their smell and touch senses at the same time.



Figure 1. Plant Cell 3D.

Material: A computer or digital board, printed labels with the name of the different cell components, scented Play Dough of different colours, chopsticks, paper and pens.

Timing: A session of approximately 2 hours.

Senses involved:



Source: Austin Visuals 3D Animation Studio. (2016, November 8). Austin Visuals 3D Animation Studio | Plant Cell | Explainer Video | Animated Video Company [Video]. Youtube. <https://www.youtube.com/watch?v=xGEoK8kRNoQ>.

Figure 1. Nedovis, A. (2013). Plant Cell 3D model [Digital image]. Shutterstock. Retrieved 15 May 2022, from <https://www.turbosquid.com/3d-models/plant-cells-3d-model-1449619>

4 Chloroplasts and chlorophyll experiment

Description: To help students figure out the reason why plants are green, what a pigment is and how it enables plants to absorb the energy they need to build tissues (photosynthesis), we will conduct an experiment to extract the pigment and use it for painting or dyeing purposes.

Steps:

1. Remove the stems.
2. Process the leaves with a blender or squeeze them with a mortar and pestle.
3. Warm up half a cup of water in a pot and place a glass inside it with two tablespoons of alcohol.
4. Insert the processed leaves into the jar.

Figure 10. Third part of the guide-activities taught through multisensory approach.

5. Once the alcohol turns green, use gauzes to press the leaves and squeeze them to obtain the liquid.

6. Put the remaining liquid on a glass and use it as ink to paint with brushes on a paper.



Material: Fresh Maple leaves, alcohol, a blender or a mortar and pestle, two glasses, gauzes, brushes and paper.

Timing: A session of approximately 1 hour 30 minutes.

Senses involved:   



Source: Alexandra, E. (2015, October 13). Maple Leaf Science: how to extract chlorophyll and paint a duck. Kid Minds. <https://kidminds.org/maple-leaf-science-how-to-extract/>

5 Colour changes experiment

Description: Through this activity children understand how plants drink water, absorb it through their roots, into their stem and to the petals using capillary action.

- **Steps to dye white flowers:**

1. Pour the water into the glasses and dye each of them with food colouring.
2. Place one flower in each glass and wait for the results between 36 and 48 hours.

- **Steps to dye a rose into many colours:**

1. Cut the stem of a white rose into three branches.
2. Put each of them on a different colour and wait for some minutes.

Material: White flowers, water, glasses and food colouring.

Timing: A session of approximately 30 minutes to perform, but the flowers will have stayed around 48 hours in the liquid to absorb the colour.

Senses involved:  



Source: Messy little monster. (2020, April 19). Colour changing flowers science experiment. <https://www.messylittlemonster.com/2018/07/colour-changing-flower-science-experiment-preschoolers.html>

Figure 11. Third part of the guide-activities taught through multisensory approach.

3.2. Types of plants

1 Nature scavenger hunt

Description: To conduct this activity we will bring students to a nearby park, botanical garden or forest. This time they will be divided in teams of 4, each team will have a worksheet and a pen. In the worksheet they will find a drawing and the name of some types of plants, fruits and leaves such as: bush, fern, flower, tree, grass, pine cone, leaf with smooth edges, leaf with serrated edges, leaf with lobes, dry leaves...(the items can be adapted depending on the local plants and the content we want them to learn).

When students see the elements that appear on their list they will make a cross, the winning team will be the one to find first all the elements.

Material: Printed worksheets and pens.

Timing: A session of approximately 1 hour.

Main senses involved:  



Figure 2. WandererDesignShop. (2013). Printable leaf identification nature scavenger hunt [Digital image]. Etsy. Retrieved 24 May 2022, from <https://www.etsy.com/listing/708859063/printable-leaf-identification-nature>.



Figure 2.

2 Classification of plants - Sorting images & real objects

Description: In order to differentiate the main types of plants we will provide students with a dichotomous key and images or real: pine cones, algae, mosses, flowers, ferns and conifers.

Children will form groups of 5 and each group will have a basket full of images of the types of plants mentioned above and some real examples. Their task will be to look at the dichotomous key and decide which type of plant is each. They will write their conclusions on a paper.

Material: Baskets, printed images, a printed dichotomous key per group and real plants, flowers or fruits, paper and pencils.

Timing: A session of approximately 1 hour.

Main senses involved:  

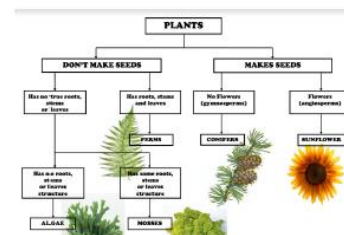


Figure 3.



Figure 3. Plant Classification Chart. (2022). Dichotomous Key [Digital image]. Retrieved 6 May 2022, from https://drive.google.com/file/d/0B4GeOqf0oLleOGJtWHptUmxlalE/view?resourcekey=0-U-E-yn_JvFuw7sMWCo-qA.

Figure 12. Third part of the guide-activities taught through multisensory approach.

3 Evergreen and deciduous trees - Projecting images & playing memory

Description: To teach the difference between evergreen and deciduous trees, we will project videos of different types of forests to hear the animals that habit them and to see how they change over the course of the year. After that, we will show images of different evergreen and deciduous trees, and we will ask them to find the differences, adding more information if its necessary.

To make the lesson more dynamic, we will group the kids, and they will play memory with A4 cards on the floor matching images of trees with their name and description.

Material: A projector or digital board and printed A4 cards (2 sets).

Timing: A session of approximately 1 hour.

Main senses involved:



Figure 4.



Figure 4. Holly, E. (2022). Troba la fulla. Un joc de memòria. [Digital image]. Experimenta. Retrieved 10 May 2022, from <https://www.experimenta.club/portfolio/troba-la-fulla-un-joc-de-memoria/>

3.3. Life cycle of plants

1 The cycle

Description: To learn the cycle of a plant, a manipulative material that shows the process of germination and sprouting of a seed (Figure 5) and name tags with the steps of the cycle will be used. Children will sit in small groups of 3 or 4 to put in order the material and will put under each object the corresponding name tag.

If the material is not available in the school, images of the process can be laminated and used to do the same activity. When all the groups have finished, they can create one poster to hang in the classroom.

Material: Plant cycle name tags, manipulative material or images of a plant going through the cycle.

Timing: A session of approximately 1 hour.

Main senses involved:



Figure 5.



Figure 5. Independent Living. (2022). Life Cycle of a Green Bean Plant [Digital image]. Retrieved 10 May 2022, from <https://www.independent-living.shop/en/product/lifecycle-bean/>

Figure 13. Third part of the guide-activities taught through multisensory approach.

2 Growing green beans & experimenting

Description: When teaching plants, the most effective way to experience them is by growing some. In this case, we will use green beans as they are fast to grow, but this activity could be conducted with any other legumes seed.

All students will have a green bean seed, a plastic bag and a paper towel. They will plant the bean in the bag with the paper towel to retain the water. To finish they will water the paper by spraying on it.

Once everyone has planted their bean, an experiment will be conducted. Some students will leave their planted seed in a place with light, others in the dark, some will leave the bag open and others closed and some will water it regularly, but others won't.

The following days, students will keep track of the seeds' evolution making hypothesis and contrasting them with the results. We can ask children to fill in a diary with the daily observations.

Material: Seeds, small plastic bags, tape, paper towels and water.

Timing: A session of approximately 20 minutes for planting and sticking them in one place. However, the plants must be checked on a daily basis during weeks to see the evolution.

Main senses involved:



3.4. Parts of a plant

1 Plant parts song

Description: To help students memorise the different parts of the flowers we will use music and dance. We will watch a video of a karaoke song that talks about the different parts and their function. The aims are that students sing and learn the lyrics and moves.



Material: A projector or a digital board.

Timing: A session of approximately 20 minutes.

Main senses involved:



Source: GenerationGenius. (2019, December 12). The Plant Parts SONG | Science for Kids | Grades K-2 [Video]. Youtube. <https://www.youtube.com/watch?v=2zvGv8yVE9s>

Figure 14. Third part of the guide-activities taught through multisensory approach.

2 Edible plants

Description: Through this activity, students will learn how all the parts of a plant can be eaten. They will bring to class different fruits, vegetables and seeds (a different one each student). As a group we will discuss from which plants we eat the roots, stems, leaves, seeds or flower.

Later on, each student will be given a worksheet in which they will create a flower by cutting and glueing the food elements they brought. Each part should be in the correct place, for instance, lettuce must be placed by as a leaf.

Material: Printed worksheets, pencils, glue, tape, knives, different vegetables and seeds. For example: lettuce, carrot, celery, broccoli...

Timing: A session of approximately 1 hour.

Main senses involved:  



Source: Blossomsandbookworms. (2019, June 25). I can eat the whole plant! A Lesson on Parts of a Plant.
<https://blossomsandbookworms.com/2019/06/25/i-can-eat-the-whole-plant/>



3 Tasting flowers and herbs

Description: Vegetables are hard to eat in class as most of them must be cooked before, yet some flowers and herbs can be eaten without preparation.

We will involve the sense of taste by preparing tasting jars with edible flowers such as sunflower petals, cornflowers, nasturtiums, pansies and herbs like mint, basil, parsley or lemongrass.

Students will take part in two main activities, on the first one, they will pair some laminated cards with the name and image of the plants to the jars that contain them. On the second one, with their eyes covered the teacher will ask them to pick a jar and taste what is inside, they will describe the taste and will uncover their eyes to say which plant they have eaten.

The activity can be done as a class and to keep all learners active, we can ask them to draw the flowers and herbs and to write next to the drawing their taste.

Material: Jars, edible flowers and herbs, a cloth to cover the eyes, laminated images with names of the plants and herbs, paper, colours and pencils.

Timing: A session of approximately 1 hour.

Main senses involved:   

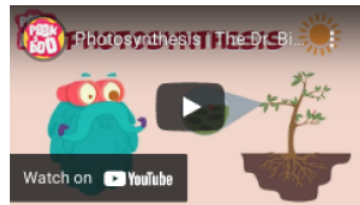
Figure 15. Third part of the guide-activities taught through multisensory approach.

3.4. Plants nutrition

1 Photosynthesis - Video, experiment, theatre and 3D poster

Description: Photosynthesis is one of the hardest topics to teach when it comes to plants as it is not possible to physically see some parts of the chemical reaction. That is why the activity is divided in four tasks.

Task 1: Students will watch a cartoon video that explains the process and will get their attention due to the format <https://www.youtube.com/watch?v=xGEoK8kRNoQ>. This will stimulate students sight and hearing senses.



Task 2: The teacher will demonstrate by covering a plant with a bag for some minutes how it gets wet due to the process of the leaves absorbing water which travelled from the roots to the stem and lastly to the leaves. Learners can discuss what would happen if a plant doesn't get water or sun and why are them some important.

Task 3: Theatre. In order to incorporate embodied learning and to address more learning styles this lesson will be physically represented. Each student will choose to be one of the following elements: sunlight, soil, water, nutrients, oxygen, carbon dioxide, chloroplasts, sugar or a plant.

The plants will lay down in the middle of the classroom with their arms open and the other elements will move around the class representing the action that the teacher calls out as she reads a text describing the process of photosynthesis.

Task 4: Groups of four will be formed and they will create a photosynthesis 3D poster. Markers, pens, cardboard and foam paper of different colours will be available for them to create it. It is important to allow students to check the information they will represent on a computer or science books.

Material: A computer or digital board, markers, cardboard and foam paper of different colours and scissors.

Timing: A session of approximately 2 hours.

Senses involved: 



Source: Peekaboo Kidz. (2015, May 13). Photosynthesis | The Dr. Binocs Show | Learn Videos For Kids [Video]. Youtube. <https://www.youtube.com/watch?v=D1Ymc311XS8>

Figure 16. Third part of the guide-activities taught through multisensory approach.

3.5. Plants reproduction

1 Dissecting a flower

Description: Students will bring a flower which they will cut in different pieces to learn the name of each part and its function. Later on, they will glue everything to a cardboard. In this hands-on task, children will manipulate the flower separating it by its main parts so longer lasting memories will be created.



Material: Fresh flowering plants, glass or cup with water, paper plates, tweezers, scissors, paper, coloured pencils and tape.

Timing: A session of approximately 1 hour.

Main senses involved:   



Source: Biology class tutorial. (2022, September). Angiosperm Dissection Tutorial [Blog entry]. Blogspot. Retrieved on May 7th from <http://biologygeeker.blogspot.com/p/angiosperm-dissection-tutorial.html>

2 Flower reproduction puzzle on stones

Description: To teach how flowering plants reproduce, students will sit in groups to create together a stone puzzle. They will look at a projected image of the different parts of a flower that assist in the reproduction process and will draw each of them on a stone with acrylic paint and permanent markers.

While the stones are drying, the teacher will explain or project videos on how the reproduction occurs.

Once the stones are ready, students will place them together to recreate the information that the teacher has explained. They will be able to check the other groups' work and comment on their art pieces.

Material: Acrylic paint, permanent markers, flat stones and a projector or digital board.

Timing: A session of approximately 1 hour 30.

Main senses involved:   



Figure 6.



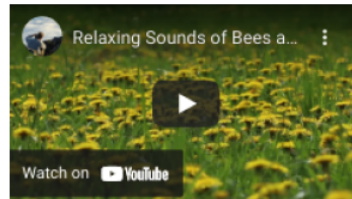
Figure 5. Independent Living. (2022). Life Cycle of a Green Bean Plant [Digital image]. Retrieved 10 May 2022, from <https://www.independent-living.shop/en/product/lifecycle-bean/>

Figure 17. Third part of the guide-activities taught through multisensory approach.

3 Pollination & insect sounds

Description: To initiate this activity we will project a video with sounds of bees and birds, and we will ask students if they know what is their function with plants (pollination).

After the video, students will be divided in pairs and each will have a set of flowers and a set of pollinators with a riddle written next to them. The task will consist on matching each animal with the flower they pollinate. This way students will understand how flowers' shape, scent and colours are adaptations to attract pollinators.



Material: A projector or a digital board, laminated cards with riddles and images of the flowers and animal pollinators.

Timing: A session of approximately 1 hour.

Main senses involved:   



Source: Relaxing Sounds of Nature. (2016, May 15). Relaxing Sounds of Bees and Birds / Bees Collecting Pollen 1 Hour [Video]. Youtube. https://www.youtube.com/watch?v=iiiDT_XoZIs

4 Flower smelling game

Description: This exercise will make students feel like insects smelling their flowers. Different flowers will be placed inside jars with wholes and students will have to guess with their eyes close what scent are they smelling.

If we want to make it harder, we can ask students to match flower name tags to each jar.

Like the tasting flowers activity, it can be done as a class, so to keep all learners active, we can ask them to draw the flowers they smell and write next to the drawing a description of how they felt with that smell. Some smells may seem sweet and calming and others may remind them of summer.

Material: Baskets, real plants flowers and herbs, smelling jars.

Timing: A session of approximately 1 hour.

Main senses involved:  



Source: Theinspiredspeechmama. (2022). DIY olfactory (smell) Jars. <https://theinspiredspeechmama.com/diy-olfactory-smell-jars/?v=920f83e594a1>

Figure 18. Third part of the guide-activities taught through multisensory approach.

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Figure 19. Third part of the guide-activities taught through multisensory approach.

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Figure 20. Third part of the guide-activities taught through multisensory approach.

ANNEX 2. DATA COLLECTION INSTRUMENTS

Name:	3 rd Grade	Date:
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Plants test

1. What happens when we **uproot** plants? Can they grow again?

2. Put in order (1 to 5) the steps involved in the **plant cycle** and match them with the corresponding picture.

- ____ Stems grow pushing up towards the light and roots grow down into the soil.
- ____ Photosynthesis. Leaves unfold and take in sunlight to produce food while flowers bloom.
- ____ Pollination, in this step seeds and fruits are produced.
- ____ The seed. Seeds hold inside a tiny plant and a food supply protected by a seed coat.
- ____ Germination. The plant becomes a sprout and begins to grow thanks to water, soil and sun.



3. Name the following **types of plants**:



4. Name all the **parts of a plant** and give one example of an **eatable** plant for each part.
For example: sunflower seeds.

Figure 21. Pre- and post-knowledge test.

5. What **type of tree** changes its colours in autumn? What would be the opposite?



- Their leaves fall down annually: deciduous / evergreen
- Stay the same all the seasons: deciduous / evergreen

Why do the leaves of the first type change colour?

6. Match the following names, pictures and **characteristics of plants**.

A type of plant that makes seeds and produces flowers.

A type of plant, which doesn't make seeds. It has roots, stem and leaves.

A type of plant, which doesn't make seeds. Has no roots, stem or leaves structure.

A type of plant that makes seeds, but not flowers.

A type of plant that doesn't make seeds. Has some roots, stem or leaves structure.



ALGAE

SUNFLOWER

CONIFERS

FERNS

MOSES

7. What is the **process** by which plants **make their own food**? Write the name on the box and complete the text below which describes it.

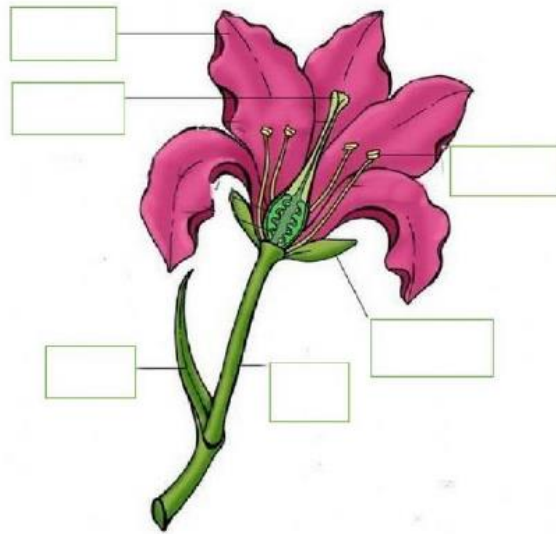
Is the process by which plants absorb _____ and convert carbon dioxide and _____ into food. Plants breathe _____ in and breathe oxygen out. Inside the plant's cells there are chloroplasts, which are the structures where we can find _____, the compound that captures sunlight and gives colour to plants.

Figure 22. Pre- and post-knowledge test.

8. Which **part** of the flower does each **function**? *stem-flower-petal- leaf- root*

- _____ Carries water and food from the roots to the rest of the plant.
- _____ Is colourful attracts insects and makes fruit.
- _____ Hold the plant to the soil and absorb the nutrients and water from the soil.
- _____ Uses the air and sunlight to make food for the plant.
- _____ You can find the seeds.

9. Name the parts of this flower: *stamen-stem-petal-pistil-sepal-leaf*



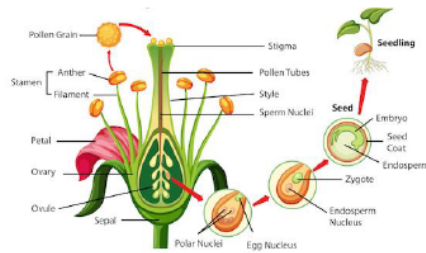
10. What colour does **chlorophyll** bring to plants? Can we change the colour of a flower?
Which parts are going to be dyed and how will the pigment (colour) travel there?

11. How would these animals interact with the plant?



Figure 23. Pre- and post-knowledge test.

12. Look at the image and complete the text about **flower's reproduction** and **pollination** with the following words: *insects-germinates-stamen-carpels-pistil-ovule*



The male part of the flower is called _____ and the female parts _____ or _____.

New plants are produced when a grain of pollen joins an _____.

Plants disperse their pollen thanks to the air and also through the help of pollinators which can be mammals, reptiles, birds and most commonly _____.

Pollination starts when pollen enters a flower's stigma and it _____ in order to travel through the pollen tube to the ovule.

Figure 24. Pre- and post-knowledge test.