Summer Internship Programme 2024
School of Mathematical and Statistical Sciences

Contribution to development of the *Figuring Out Y* initiative through pedagogical design

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Introduction

This document outlines my work throughout the research Internship Programme with the School of Mathematical and Statistical Sciences in summer 2024. My work contributed to the research and outreach project *Figuring Out Y (FOY)*, working with founder Dr. Emma Holian and collaborator Dr Mairead Greene.

Figuring Out Y (FOY) is an initiative aimed at improving community engagement and education in STEAM with particular emphasis on mathematics through local environment application. The initiative has a number of distinct strands of focus aimed at raising awareness of mathematics in children's literature and games, and pedagogical research. Activities in development include whole community-orientated *Hidden Figures Hunt* and the creation of a website to share community reviews of literature and games with some mathematical focus.

Within the timeframe afforded of the Summer Internship, I contributed to the development of the *Hidden Figures Hunt*, to create a bank of questions and design an example prototype for demonstration. In addition, to inform the creation of the bank of questions, I conducted a literature review of numeracy community engagement initiatives, strategies and their reported impacts.

I. Description of *The Hidden Figures Hunt*

The vision for *Hidden Figures Hunt* is a local community-based event that engages families in a hunt for key items in their locality linked to mathematical and statistical concepts. The "*Hidden Figures Hunt*" will be designed with a generic pedagogically-designed set of questions, which is then tailored to the locality by a local organisation team, consisting of FOY personnel working with local community, (e.g. 2nd level student volunteers, businesses and societies, local educators and school parental associations). The children practice every-day numeracy skills like number sense and problem solving, improving the underlying mathematical concepts outside of the classroom. By moving around the locality, the children are in a fun and real-life application context. The question bank is to be informed by the primary and secondary mathematics curriculum and linked to pedagogical strategies in literature. Importantly, the *Hidden Figures Hunt* deployment design and its questions are created to be accessible to all audiences, so as to, subtly, inspire the reluctant learner, inspiring confidence in the children and support families in how they can take more of a role in the mathematics education of their children by local community application of mathematics.

II. Context and Literature Review

In the context of the *Hidden Figures Hunt* we conduct a literature review, focused on identifying and reviewing impacts of community-engagement mathematics initiatives internationally, identifying and highlighting local mathematics initiatives, which sets the context of the aims of the *Figuring out Y* initiative and motivation for development of the *Hidden Figures Hunt* activity.

Using Google Scholar, searches were conducted with keywords; "community-based initiative", "numeracy outcomes", "attitude towards mathematics", "children"; "disadvantaged areas", "parental involvement", "evidenced-based activities".

The promotion of mathematical thinking in the local environment is discussed in the paper *van Oers (2010), which describes 'Development Education'* in the Netherlands through the context of play. This paper describes the cultural-historical approach to learning and in that context lists five conditions of particular importance; *meaningful learning*, *participation in cultural practices*, *help from more knowledgeable others*, *leading activity* and *communication*. The research investigated *guided co-construction,* a collaborative peer process amongst primary school pupils guided by their teachers, in order to create their own learning models to mathematical concepts. When "the child may perform unintentionally, … an action or utter a word or sentence which may be taken as mathematical", it is "only when the adult reacts in a mathematical way to this action…does the child's action begin to gain mathematical meaning, especially when this is noticed by the child". The emergence of mathematical thinking is 'projected' into the child's mind in the process of cultural interactions with others. An important condition for the emergence of mathematical thinking in the early years is the adults' act of articulating spontaneous actions of the child and if appropriate assigning mathematical meaning to it. Similarly, it is observed that children's spontaneous actions of drawing or scribbles have clear communication intentions for the child

with the help of creating their own symbol representation, however, many opportunities to promote this emergent mathematical thinking can often be missed. Missing this opportunity along with the imposition of new formal mathematical symbols (like numbers and operators) can cause a gap, having no way of transforming the child's personal understandings and notations into new mathematical ones. The research points out the importance of the role of a more knowledgeable other (teacher, parent) in articulating child's personal marks and actions and promoting a shared mathematical meaning to them, thus promoting collaborative problem solving.

In Ireland, the concept of learning through play, is promoted in *Síolta* the National Quality Framework for Early Childhood Education (CECDE 2006) and *Aistear*, the Early Childhood Curriculum Framework (NCCA 2009).

Bleach (2015) emphasise the importance of "providing a continuum of services for the whole child linking and integrating child, family, local services and the community" as guided by the National Early Years Access Initiative, NEYAI, (Pobal 2010), in developing the *Early Learning Initiative (ELI)* through the National College of Ireland. In this paper, Bleach describes improving numeracy outcomes for children through community action research. The aim of the initiative was to improve the numeracy skills of the child and their family, focusing on socio-economically disadvantaged children, aged 6 years old or less, who attended ECCE services in the Dublin Docklands area. The ELI engaged with local community bodies such as Early Childhood Care and Education Program (ECCE) services, schools and health services along with statutory and corporate organisations. Workshops were organised by the ELI numeracy team to guide parents in the teaching of their children and to support their children's education by creating a learning community. Within the workshops, in collaboration, action plans were used to develop materials for the numeracy week, and training sessions for ECCE practitioners and parents. The paper does not provide a description of the children's activities but outlined that they followed themes on the national primary mathematics curriculum (shape, space, measures, pattern, sequencing and number). In measuring impacts with respect to the children's numeracy outcomes, and the impacts on ECCE practitioners and parents, external and internal evaluations were carried out. Through the community action research approach, they observed positive feedback from educators on their reflection of working with parents. For example, one educator said that "*The children loved the activity week. They were highly involved in all the games/activities and they created their own game of find the shape in the room and match it to the wall chart.*"; and "*We got positive feedback. Parents told me that the children were scanning everything on their way home looking for circles, squares, triangles and rectangles. One parent said 'I didn't realise we could look at shapes in everyday things walking home'*." There were measurable gains in the children's numeracy outcomes, with test results post-initiative being on par with the national average, and there was a change in parents' attitudes towards supporting their children's numeracy outcomes. There are specific references to increased recognition of geometry in the real world, and greater excitement in the children about mathematics.

Parental involvement is also investigated in *Fitzgerald et al* (2019), in discussing the effects of shared picture book reading in developing their child's mathematical education. In this paper, a

literature review is first presented, supporting the case for consideration of shared picture book reading as the intervention tool. Many studies cited in the paper indicate that storytelling through the medium of text and pictures allow children to encounter problems in a meaningful context. Shared reading gives opportunity for discussion and the use of mathematical language between parent and child, allowing children to actively construct new knowledge in a social environment. *Fitzgerald et al* study whether parental involvement in mathematics can be enhanced through shared picture book reading, measuring the impacts through a small-scale observational study in Ireland, a primary school in County Kildare, engaging 1st class aged children and their parents. A pre-intervention questionnaire on parental attitudes towards their role or extent of involvement in mathematics education of their child, indicated that attitudes had been influenced by their own past experiences of mathematics in school. Parents can be more aware of how to engage children in literacy activities in the home but often struggle to incorporate mathematical activities beyond the scope of school homework. During the intervention, parents enjoyed having a greater role to play in their child's mathematics education "*definitely as a family we all became more aware of how you can learn maths through reading and through books.*" Parental involvement had increased, reporting increased confidence in parental engagement, and parents reported increased motivation on the part of the children.

With consideration to extending mathematics education, beyond the classroom, to whole-of-community initiatives, we reference an example described and evaluated in *Ollerenshaw et al (2012)*, the *Moorabool Literacy Trails***,** Moorabool Shire, Victoria, Australia. The Literacy Trails activity was established by committed educational and community partners, through the *Moorabool Shire Best Start Partnership,* seeking to promote and nurture children's awareness of literacy and numeracy and increase capacity of community participation, by facilitating local community involvement as a whole-of-community approach. The Literacy Trials are held annually during National Literacy and Numeracy Week, as half-day events, inviting children to gather in the main shopping centre of the town to engage in activities, games, street performances and storytelling that have a focus on reading, writing and/or numeracy. The success and uniqueness are attributed to the commitment and participation of the community, e.g. local business owners, senior citizens club, local clubs and community agency workers, all playing key roles, by sharing interest, by dressing up, storytelling and demonstration with the children from local schools. The event provided an important message about literacy and numeracy which would be reinforced through 'take-home' material that children were given to share with their parents. In undertaking a formal impact evaluation of an initiative, involving evaluation of both qualitative and quantitative data through various methodological tools such as questionnaires, interviews, focus group feedback, analysis of previous program evaluation data, and anecdotal information, *Ollerenshaw et al* (2012) indicated strong evidence that the project achieved its aims. Insights from parental feedback in the evaluation indicated success of the Literacy Tails in observing changes in the child's literacy and numeracy behaviours. Responses such as "*My child has gained increasing confidence in numeracy… she was hesitant before but with projects like yours she gives it a try*", "*(My child is) more keen to visit the library and helping with shopping*.", and *"My child is wanting to read more and is counting, every day*." shows the child's awareness of numeracy in everyday

applications such as shopping, an increased interest in books, and their increased confidence in wanting to participate, and in increased parental involvement in their children's education. The project achieved the effect of having whole-of-town involvement and places an emphasis on collaborative efforts and *community strength* as a factor in the initiative's successful impact.

Recognising other noteworthy impactful outreach activities internationally, *MoMath New York* is a mathematics museum in New York, USA aimed at any K-12-grade students and older. Some interesting points were that the museum allows visitors to play around with and explore maths phenomenon not encountered normally at K-12 level. The museum also tries to disassociate maths from the stigma built up in schools. Visitors' perceptions of shapes and space are redefined through totally new experiences with these concepts. According to an article by the New York Times, the museum is focused on 'fun' rather than 'illumination', and "*many math museums [...] the enthusiasm the subject inspires is not easily communicated and not readily discovered*" but *MoMath* succeeds in doing this. There exists an "Expansions" program aimed at mathematically gifted students enrolled in 1st through 12th grades. The program allows the children to learn about advanced topics like topology and fractals.

In Ireland, *Maths Week*, is a nationwide mathematics promotion and awareness initiative, held annually every October, engaging children and adults in competitive but fun mathematical games and activities. While its core principle is 'Maths for all', i.e. believing that maths is useful for all no matter their age, background or ability, Maths Week is mainly targeted at schools, primary and secondary, encouraging opportunity for teachers to spread new ideas in maths education. This creates a space "*whereby teachers can try out new ideas and invent and create activities with their pupils*".

Also in Ireland, with similar focus, *'Maths Eyes'* is a project dedicated to helping individuals of all ages and backgrounds discover the maths they use in their everyday lives, by hosting promotional competitions and developing materials for local activities. 'Maths Eyes' activities began in Tallaght, Dublin, in 2011, and the initiative has since extended nationally and internationally, to include activities in the classroom and in the community such as workshops, maths trail examples, and developing example resource packs. An impact study of the was initiated in 2014, reporting in *Maguire et al (2018)*, highlighting maths "*for life, for careers, and as part of our culture"*. Indeed, they report that 85% of teachers felt participation in a Maths Week event improved their pupils' attitude towards maths.

Mathematics enrichment programmes implemented local to the Galway community include University of Galway, *Junior and Senior Mathematics Enrichment Programmes*, *Maths Olympiad*, University of Galway *Youth Academy Mathematics Module*, and *TYFridays*, these being aimed at primary and secondary school children displaying an advanced ability in mathematics or serve as an outreach activity to provide awareness of mathematics degree programmes opportunities. Local community and family engagement initiatives that embrace mathematics for all sections of society and abilities, include annual events *"Galway Science & Technology Festival*," and "*Engineering Our Future: Family Fun Day*", University of Galway. The Galway Science & Technology

Festival is a collection of exhibits, workshops and shows, celebrating science in our everyday lives, sponsored by local research ventures and industry. One such noteworthy exhibit showcases the "*Mathpalooza*" initiative, a mathematics outreach programme for all ages promoting "*Math through Play*" *(Guadarrama and Greene)*.

Kennedy et al. (2023), Towards a New Literacy, Numeracy and Digital Literacy Strategy – A Literature Review, was commissioned by the Irish Department of Education to inform policy. The review is organised into three parts. Part A focusing on policy-making in the Irish national context, a description and assessment of past strategies and a comparison to some large-scale international initiatives to improve literacy, digital literacy and numeracy. Part B explores pedagogical strategies, approaches and methodologies to support literacy and numeracy internationally, supported by a wide range of cited papers. Part C draws together the conclusions and recommendations arising from Parts A and B, presented under each of the six pillars of the National Literacy and Numeracy Strategy.

In referencing the sections of *Kennedy et al. (2023) which align to the motivational context o*f the FOY initiative, these are; subsection B2 *pedagogical strategies in relation to numeracy development,* subsection B6 e*ngaging parents and communities,* and subsection B4 *supporting literacy and numeracy development of diverse learners across the curriculum,* as FOY is to give particular focus on ensuring access for children in marginalised communities.

Kennedy et al. (2023) discusses the definition of numeracy, in particular, as being "r*elevant to all subject areas and to real life"*; numeracy is not just used in the context of mathematics but is a basic skill for quantitative reasoning, problem solving, and other mathematical competencies needed in a range of situations in adult life. The term '*mathematical literacy*' is encountered, described as a term often used instead of 'numeracy', especially in the United States, and as something that "a*ssists individuals to know the role that mathematics plays in the world*".

Interestingly, section B2 of *Kennedy et al.*, discusses four key elements for developing numeracy. First, attention to numeracy in real-life contexts. "*[…] real-world problem-solving based on active and hands-on experiences*" should be considered to allow children to "*discover mathematical concepts in meaningful and developmentally appropriate ways"*, i.e. in ways that shows the usefulness of numeracy skills in situations children encounter daily. Second, the use of tools, representational, physical and, notably, digital, contributes to developing "*higher-order mathematical skills, such as problem-solving, mathematising and reasoning*". Thirdly, "*having a positive or productive disposition towards numeracy is identified as one of the key components towards developing mathematical proficiency in the mathematics curriculum specifications*", a positive mentality being "'t*he habitual inclination to see mathematics as sensible, useful, and worthwhile, coupled with a belief in diligence, perseverance and one's own efficacy' (NCCA, n.d.)*". Growth in this area can be aided, for example, by problem-based learning, which "*fosters […] a positive attitude towards mathematics and leads to higher mathematical gains"*. Problem-solving leads to a deeper, more intuitive understanding of numeracy skills, and their importance. Lastly, considerations to application of mathematical knowledge are discussed, such that "*mathematical*

knowledge for teaching comprises two essential elements, subject matter knowledge (the what of teaching) and pedagogical content knowledge (the how of teaching)", and given different forms of numeracy integration such as STEAM and transdisciplinary or interdisciplinary approaches.

Pertinent recommendations arising in Pillar 1: Enabling Families and Communities to Support Children's Literacy (and Numeracy) Development include:

- Parents should be encouraged to become involved in all aspects of their child's education, especially mathematics (Ramirez et al., 2013; Fan et al., 2017; Choi & Han, 2020). [Report B2.1b, *Harrison et al. (2022)*]
- Parents should be involved in identifying highly able students, and in supporting them to reach their potential, in partnership with schools (Cullen et al., 2018; Montacute, 2018). [Report B4.10, *Shiel et al. (2022)*]
- Schools should explore the community as a context for the rich and meaningful development of numeracy by students (McDonald & Smith, 2020; Merritt et al., 2017; White & Delaney, 2021). [Report B2.3, *Dooley et al. (2022)*]
- Schools should draw on and facilitate interaction with individuals/organisations in the community who can demonstrate their everyday use of numeracy (Belbase et al., 2021; White & Delaney, 2021). [Report B2.3, *Dooley et al. (2022)*]
- In general, family engagement programmes addressing literacy, digital literacy and numeracy should be developed using a partnership approach to address local needs (Jeynes, 2018; Smith et al., 2019). Such an approach will be grounded in two-way communication between families and school/setting staff and will use evidence-based activities (such as dialogic, shared reading or growth mindset messages) in flexible ways to suit the local context. [Report B6.1, *Nic Mhuirí et al. (2022)*]
- Support for persons involved in after-school programmes, book giveaway programmes, STEM initiatives, organisations involved in the promotion of literacy, libraries and museums should focus on developing leadership skills that promote engagement and cultivate partnerships between relevant agencies, institutions, settings and local communities. This would allow policy to be enacted at a local level in a way that directly impacts on children's outcomes. While community-engagement programmes should be responsive to local needs, they should also have clear goals, and be based on a well-researched theory of change or logic model which explicitly outlines the contribution from the relevant community members and expected outcomes (Gamse et al., 2017). [Report B6.2, *French et al. (2022)*]

These echo the aspirations for the FOY initiative and the design and implementation of the *Hidden Figures Hunt* being a fully supported **whole-community** numeracy initiative, Figure 1.

Figure 1: *Hidden Figures Hunt* Deployment Scheme – Whole-Community Event, community engagement at all levels.

III. Pedagogical design of the questions and development of the question bank

The pedagogical design of the FOY *Hidden Figures Hunt* is a focus on hands-on activity and relevant real-life contexts within the local community. The development of the question bank of numeracy exercises has been informed by the primary mathematics curriculum. The primary online "toolkit", see Figure 2, provides practical support, through documents made available online, to teachers wishing to create an enriching mathematical learning experience for children in the Strands studied at primary level (Algebra, Data, Measures, Number, Shape and Space).

The view "mathematical concepts", provides a mapping of the learning outcomes and mathematical concepts to be learned from Stages 1 to 4, where stage 1 are students in junior and senior infants, and stage 4 are fifth and sixth class students. An example of the mathematical concepts for the M*easures strand: Measuring* is provided in Figure 3.

The view "progression continua", details sample learning trajectory for each strand for Mathematics at primary level. The learner's learning continuum ranges from *a* to *k*, with learning outcomes for each of *Understanding & Connecting, Communicating, Reasoning and Applying & Problem Solving,* essential core concepts and skills of Mathematics. An example for the M*easures strand: Measuring* is provided in Figure 4.

Figure 2: Primary curriculum online toolkit accessed through the curriculum online website.

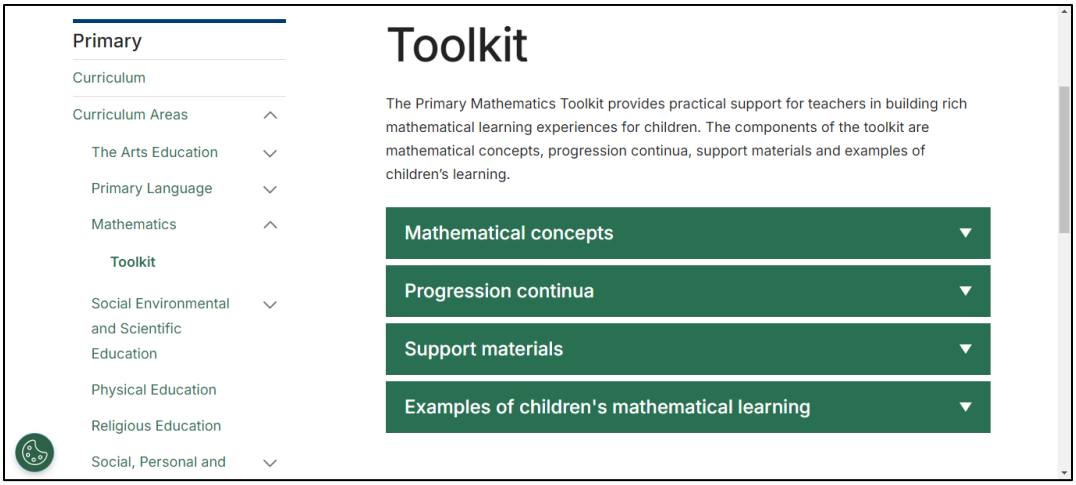
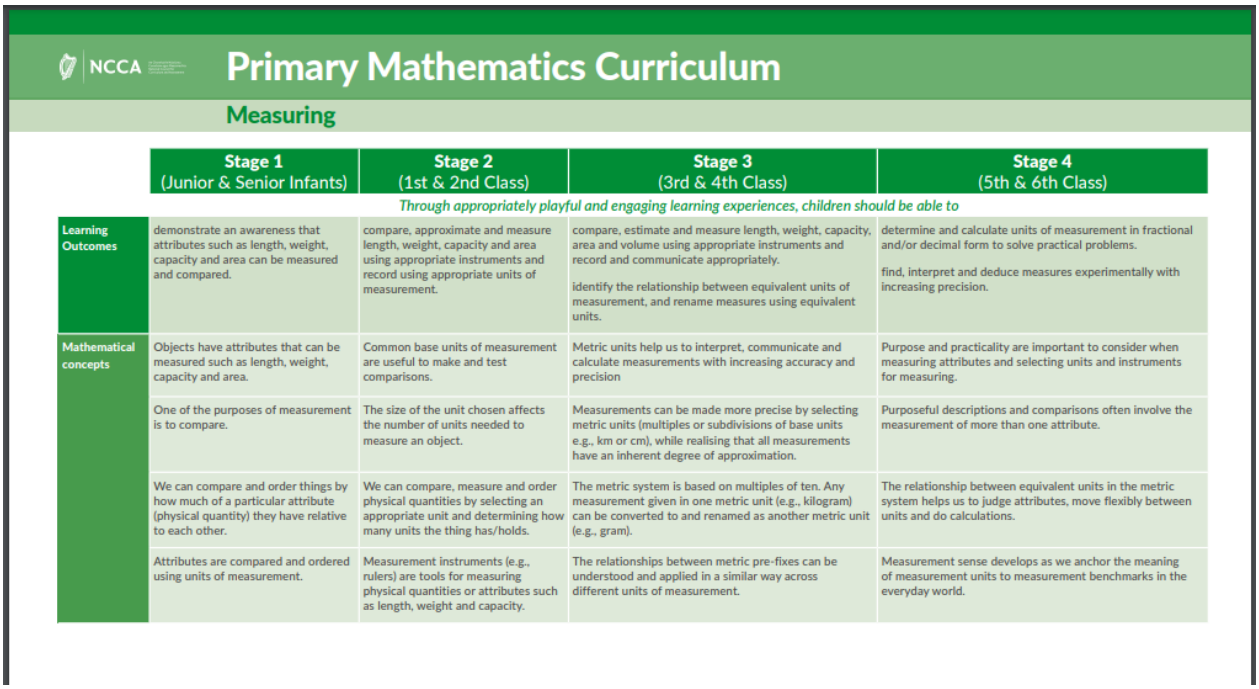


Figure 3: Primary online "toolkit" - Measures: Measuring.



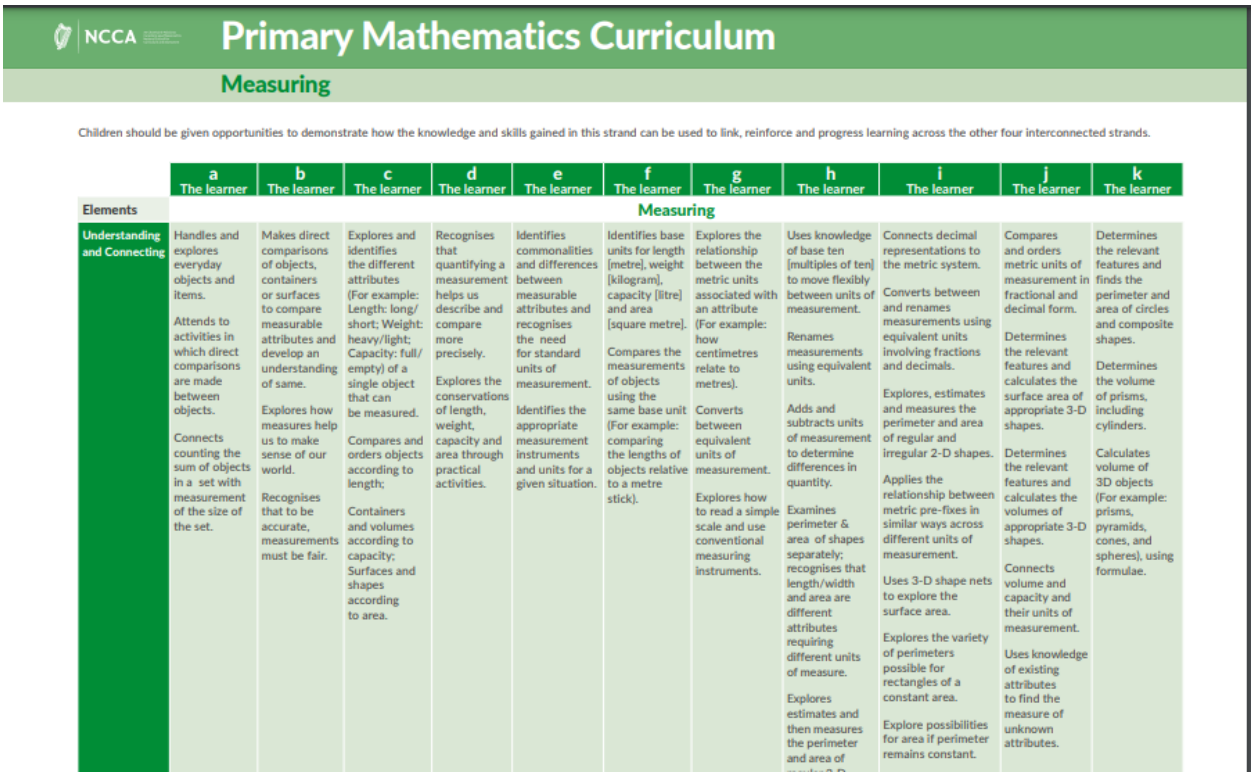
NCCA

Primary Mathematics Curriculum

Measuring

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	demonstrate an awareness that attributes such as length, weight, capacity and area can be measured and compared.	compare, approximate and measure length, weight, capacity and area using appropriate instruments and record using appropriate units of measurement.	compare, estimate and measure length, weight, capacity, area and volume using appropriate instruments and record and communicate appropriately. identify the relationship between equivalent units of measurement, and rename measures using equivalent units.	determine and calculate units of measurement in fractional and/or decimal form to solve practical problems. find, interpret and deduce measures experimentally with increasing precision.
Mathematical concepts	Objects have attributes that can be measured such as length, weight, capacity and area.	Common base units of measurement are useful to make and test comparisons.	Metric units help us to interpret, communicate and calculate measurements with increasing accuracy and precision	Purpose and practicality are important to consider when measuring attributes and selecting units and instruments for measuring.
	One of the purposes of measurement is to compare.	The size of the unit chosen affects the number of units needed to measure an object.	Measurements can be made more precise by selecting metric units (multiples or subdivisions of base units e.g., km or cm), while realising that all measurements have an inherent degree of approximation.	Purposeful descriptions and comparisons often involve the measurement of more than one attribute.
	We can compare and order things by how much of a particular attribute (physical quantity) they have relative to each other.	We can compare, measure and order physical quantities by selecting an appropriate unit and determining how many units the thing has/holds.	The metric system is based on multiples of ten. Any measurement given in one metric unit (e.g., kilogram) can be converted to and renamed as another metric unit (e.g., gram).	The relationship between equivalent units in the metric system helps us to judge attributes, move flexibly between units and do calculations.
	Attributes are compared and ordered using units of measurement.	Measurement instruments (e.g., rulers) are tools for measuring physical quantities or attributes such as length, weight and capacity.	The relationships between metric pre-fixes can be understood and applied in a similar way across different units of measurement.	Measurement sense develops as we anchor the meaning of measurement units to measurement benchmarks in the everyday world.

Figure 4: Primary online "toolkit" view 'Understanding and Connecting', an example for strand Measures: Measuring.



NCCA

Primary Mathematics Curriculum

Measuring

Children should be given opportunities to demonstrate how the knowledge and skills gained in this strand can be used to link, reinforce and progress learning across the other four interconnected strands.

	a The learner	b The learner	c The learner	d The learner	e The learner	f The learner	g The learner	h The learner	i The learner	j The learner	k The learner
Elements	Measuring										
Understanding and Connecting	Handles and explores everyday objects and items. Attends to activities in which direct comparisons are made between objects. Connects counting the sum of objects in a set with measurement of the size of the set.	Makes direct comparisons of objects, containers or surfaces to compare measurable attributes and develop an understanding of same. Explores how measures help us to make sense of our world. Recognises that to be accurate, measurements must be fair.	Explores and identifies the different attributes (For example: Length: long/ short; Weight: heavy/light; Capacity: full/ empty) of a single object that can be measured. Compares and orders objects according to length; Containers and volumes according to capacity; Surfaces and shapes according to area.	Recognises that quantifying a measurement helps us describe and compare more precisely. Explores the conservations of length, weight, capacity and area through practical activities.	Identifies commonalities and differences between measurable attributes and recognises the need for standard units of measurement. Identifies the appropriate measurement instruments and units for a given situation.	Identifies base units for length [metre], weight [kilogram], capacity [litre] and area [square metre]. Compares the measurements of objects using the same base unit (For example: comparing the lengths of objects relative to a metre stick).	Explores the relationship between the metric units associated with an attribute (For example: how centimetres relate to metres). Converts between equivalent units of measurement. Explores how to read a simple scale and use conventional measuring instruments.	Uses knowledge of base ten [multiples of ten] to move flexibly between units of measurement. Renames measurements using equivalent units. Adds and subtracts units of measurement to determine differences in quantity. Examines perimeter & area of shapes separately; recognises that length/width and area are different attributes requiring different units of measure. Explores estimates and then measures the perimeter and area of	Connects decimal representations to the metric system. Converts between and renames measurements using equivalent units involving fractions and decimals. Explores, estimates and measures the perimeter and area of regular and irregular 2-D shapes. Applies the relationship between metric pre-fixes in similar ways across different units of measurement. Uses 3-D shape nets to explore the surface area. Explores the variety of perimeters possible for rectangles of a constant area. Explore possibilities for area if perimeter remains constant.	Compares and orders metric units of measurement in fractional and decimal form. Determines the relevant features and calculates the surface area of appropriate 3-D shapes. Determines the relevant features and calculates the volumes of appropriate 3-D shapes. Connects volume and capacity and their units of measurement. Uses knowledge of existing attributes to find the measure of unknown attributes.	Determines the relevant features and finds the perimeter and area of circles and composite shapes. Determines the volume of prisms, including cylinders. Calculates volume of 3D objects (For example: prisms, pyramids, cones, and spheres), using formulae.

For discussion, examples of demonstrative questions, sampled from the FOY *Hidden Figures Hunt* Design and Development Team, are provided in Figures 5,6 & 7.

Question 1 (Figure 5) is based on the 1st and 2nd class learning outcome "using and applying different counting strategies" in the "Number: numeration and counting" strand. Question 2 (Figure 6) addresses the 1st and 2nd year learning outcome, to "examine, categorise, and model 3-D and 2-D shapes in "Shape and Space: Shape". Question 3 (Figure 7) practices the 3rd and 4th year outcome "compare, approximate and measure time using appropriate units of measurement" and the mathematical concept of timetables as "tools for managing and organising time" in the strand "Measures: Time".

The developed question bank includes questions across all strands, including other titles in the online curriculum toolkit such as "Measures: Money" and "Data and Chance". Examples include questions that practice conversion between currencies, using graphs, understanding probability and proportions, using basic arithmetic, making informed decisions about financial plans, budgeting and using basic arithmetic (see Appendix B for further examples, Figure B.4 in the context of currency exchange office, Figure B.5. in the context of budgeting).

Figure 5: *"Number: numeration and counting"* An example counting exercise.

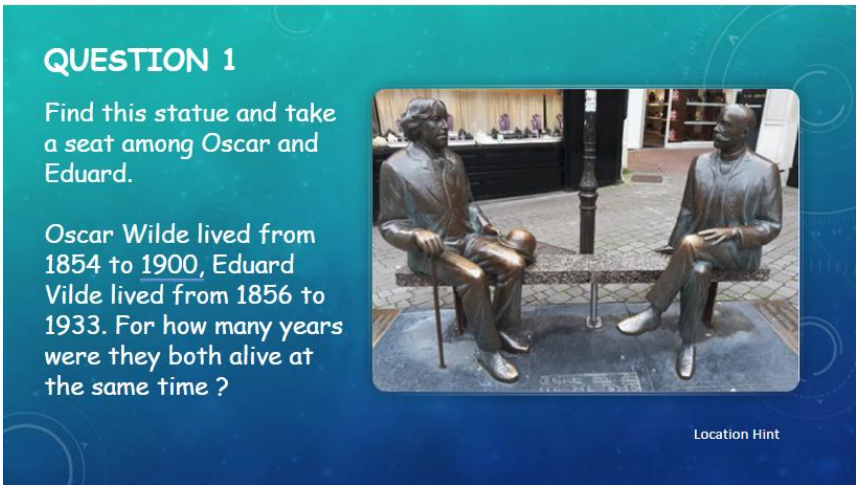


Figure 6: *"Shape and Space: Shape"*: A shape exercise.

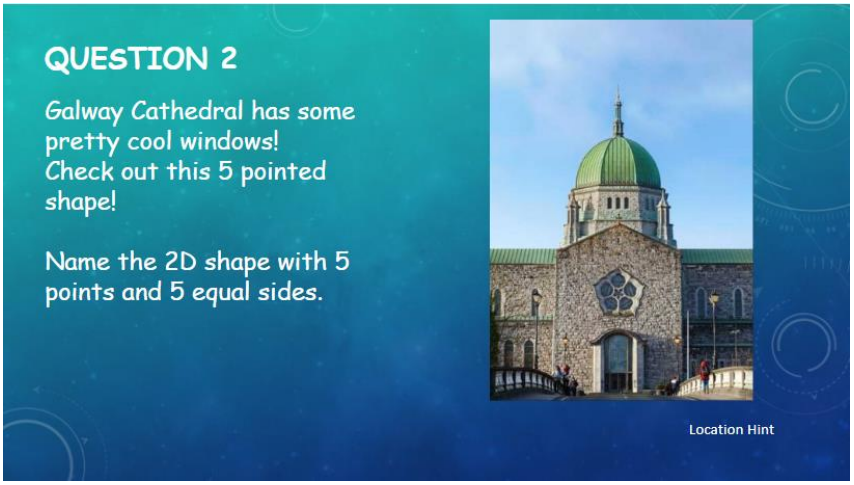
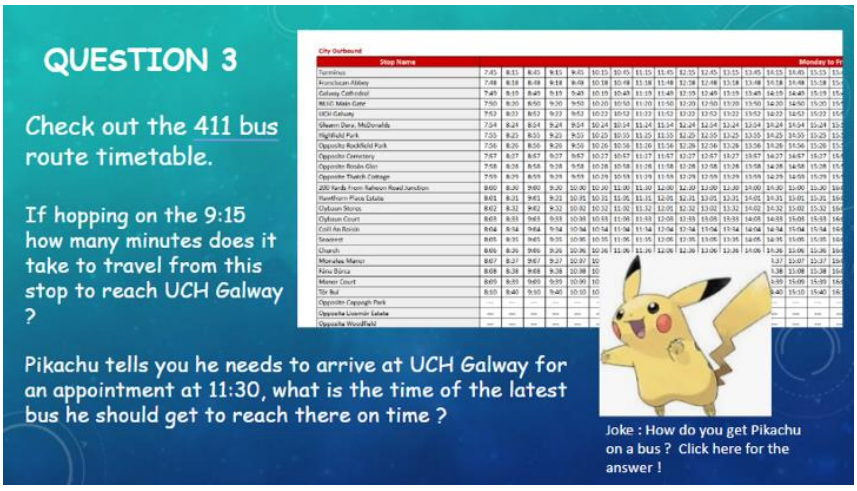


Figure 7: *"Measures: Time":* A time management exercise.



The primary online toolkit gives a guideline as to how the questions can be tailored for different difficulty levels and ages**.** For a strand, the question bank includes choice of questions, based on the same strand, but adapted with consideration as to the age and matched difficulty level of the participant. For example, for the strand "Shape and Space: Shape", a 1st and 2nd year question is to find the depth of the swimming pool at the venue or can be advanced to 5th and 6th class students by asking the children to find the volume of the swimming pool as a cuboid. Another illustration corresponding to the strand "Shape and Space: Spatial Awareness" is a question asking to estimate or measure the length of an object using a ruler or a measuring tape. Junior and Senior infant students may need to simply provide a whole number, or to choose from a narrow selection of answers, while 1st and 2nd year students may need to provide a decimal, requiring the participant to give closer attention to accuracy. Questions are designed to have a multiple-choice answer format allowing the difficulty level of the question to be tailored, as well as broadening exposure to the occurrence of different mathematical concepts in real life.

Importantly, these questions also demonstrate how questions sampled from the question bank are then tailored to be in the context of application to the locality of the participant, in this demonstration context is tailored to the locality specifically for a Galway city-based *Hidden Figures Hunt*. For instance, Question 1 (Figure 5) uses a statue in the locality, Question 2 (Figure 6) a local building, while a local bus stop is used for Question 3 (Figure 7), thereby revealing the 'Hidden Figures' in the participant's locality. This tailoring will be carried out by a *Local Community Deployment Design Team,* Figure 1, a collaboration amongst nominated Transition Year students from schools in the locality, local Businesses and societies, supported by the FOY Deployment Team. In this way we embrace whole-community awareness and engagement.

In the design of the question bank, further considerations are given to methods of deployment of the *Hidden Figures Hunt*, where the design of questions tailor for paper-based or app-based deployment. The vision is for deployment supported by an app, accessible through phones for example. With this vision, question context can include and foster application in the digital environment in the design, emerging as an important aspect in numeracy engagement activities and aligns to national strategy. The app would allow questions to provide a dynamic experience for the participant, such as interactable visualisations of the mathematical concepts, for example, 3-D models, visualisation of trends and shapes. GPS functionality can create a 'game' experience, where the next location only reveals itself after the activity at the previous location has been completed. The app allows for more complexity than a paper-based alternative, for instance, an app easily facilitates a pop-up to guide and explain the solution to a question, to provide fun facts, additional examples, or to explain what a word means. This also facilitates a way of providing access to further resource material to aid further conversations on the strand in the home and community, during and after the event.

Continuing the topic of deployment, *Hidden Figures Hunt* would seek to form partnerships with local schools, by inviting Transition Year secondary students to tailor the questions to their local area; with local educators and schools, to provide insight into linking the numeracy exercises with best practices for learning; libraries and community groups, to have a wider reach over

communities of different socioeconomic and cultural backgrounds and to implement *Hidden Figures Hunt* into successful local community events. Collaborating with local businesses and societies, the FOY design team encourage provision of endorsement and sponsorship, and in tailoring to the locality, the businesses can feature as context for a question strand or be host to a question-linked activity at the businesses, where the participants visit when taking part in the event. This builds whole-community awareness and participation of the initiative, as highlighted in the literature review exploration.

Conclusion

My research on the topic has given me a strong understanding of numeracy education. A personal point of interest is how mathematics' education involves having a positive disposition towards the subject, the development of which comes from the role played by the community, parents and guardians, and schools. This is crucial in the early years of numeracy and mathematics education and that is why outreach programs like *Figuring Out Y* are so impactful. I have also had exposure to what is required at each stage of the design of an outreach project: the conceptualising, fundamental research, getting funding, and collaboration.

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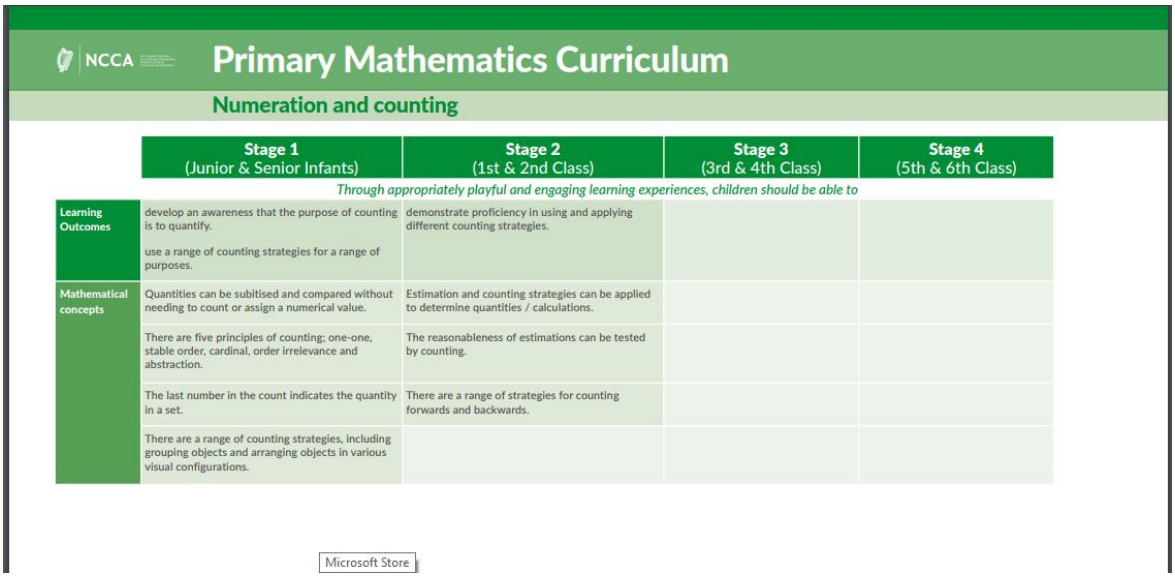
Appendix

Appendix A - Mathematical concepts in the primary mathematics online toolkit

Figure A.1. "Numeracy: Numeration and counting"



NCCA

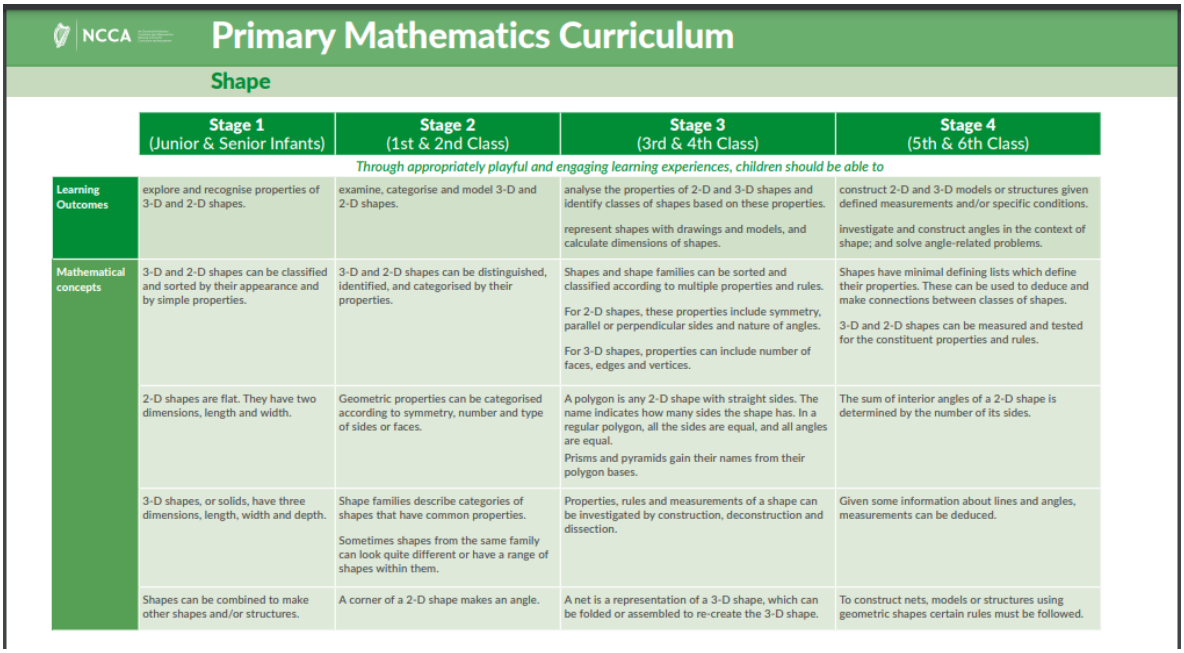
Primary Mathematics Curriculum

Numeration and counting

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	develop an awareness that the purpose of counting is to quantify. use a range of counting strategies for a range of purposes.	demonstrate proficiency in using and applying different counting strategies.		
Mathematical concepts	Quantities can be subitised and compared without needing to count or assign a numerical value.	Estimation and counting strategies can be applied to determine quantities / calculations.		
	There are five principles of counting; one-one, stable order, cardinal, order irrelevance and abstraction.	The reasonableness of estimations can be tested by counting.		
	The last number in the count indicates the quantity in a set.	There are a range of strategies for counting forwards and backwards.		
	There are a range of counting strategies, including grouping objects and arranging objects in various visual configurations.			

Microsoft Store

Figure A.2. "Space and Shape: Shape"



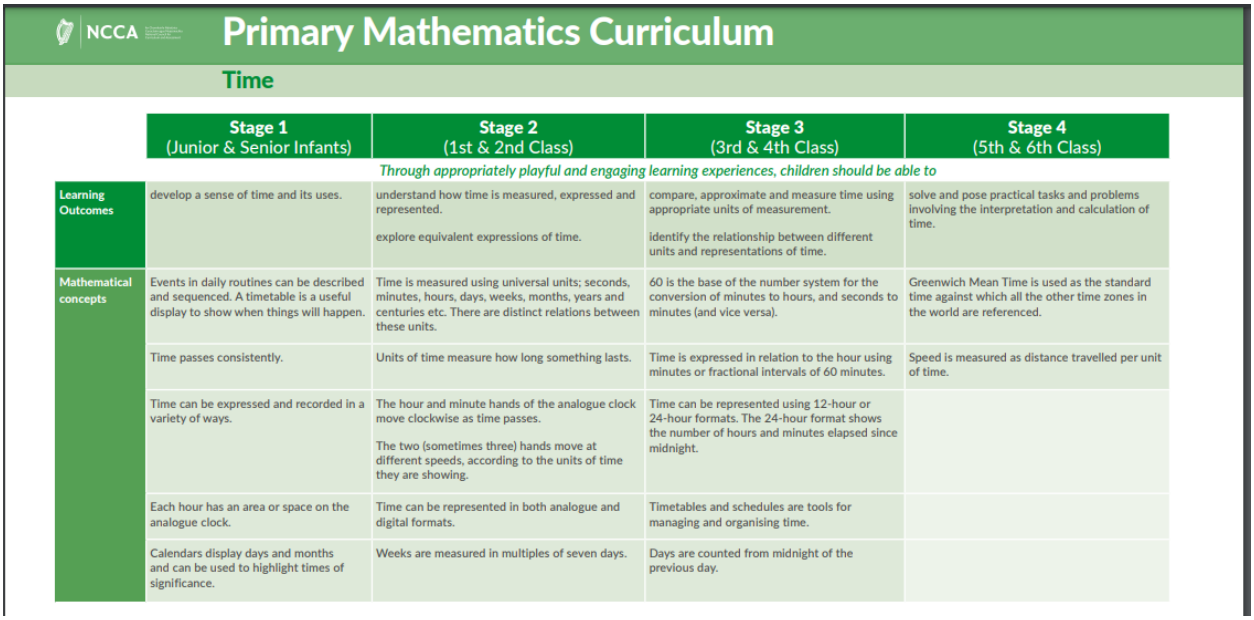
NCCA

Primary Mathematics Curriculum

Shape

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	explore and recognise properties of 3-D and 2-D shapes.	examine, categorise and model 3-D and 2-D shapes.	analyse the properties of 2-D and 3-D shapes and identify classes of shapes based on these properties. represent shapes with drawings and models, and calculate dimensions of shapes.	construct 2-D and 3-D models or structures given defined measurements and/or specific conditions. investigate and construct angles in the context of shape; and solve angle-related problems.
Mathematical concepts	3-D and 2-D shapes can be classified and sorted by their appearance and by simple properties.	3-D and 2-D shapes can be distinguished, identified, and categorised by their properties.	Shapes and shape families can be sorted and classified according to multiple properties and rules. For 2-D shapes, these properties include symmetry, parallel or perpendicular sides and nature of angles. For 3-D shapes, properties can include number of faces, edges and vertices.	Shapes have minimal defining lists which define their properties. These can be used to deduce and make connections between classes of shapes. 3-D and 2-D shapes can be measured and tested for the constituent properties and rules.
	2-D shapes are flat. They have two dimensions, length and width.	Geometric properties can be categorised according to symmetry, number and type of sides or faces.	A polygon is any 2-D shape with straight sides. The name indicates how many sides the shape has. In a regular polygon, all the sides are equal, and all angles are equal. Prisms and pyramids gain their names from their polygon bases.	The sum of interior angles of a 2-D shape is determined by the number of its sides.
	3-D shapes, or solids, have three dimensions, length, width and depth.	Shape families describe categories of shapes that have common properties. Sometimes shapes from the same family can look quite different or have a range of shapes within them.	Properties, rules and measurements of a shape can be investigated by construction, deconstruction and dissection.	Given some information about lines and angles, measurements can be deduced.
	Shapes can be combined to make other shapes and/or structures.	A corner of a 2-D shape makes an angle.	A net is a representation of a 3-D shape, which can be folded or assembled to re-create the 3-D shape.	To construct nets, models or structures using geometric shapes certain rules must be followed.

Figure A.3. ”Measures: Time”



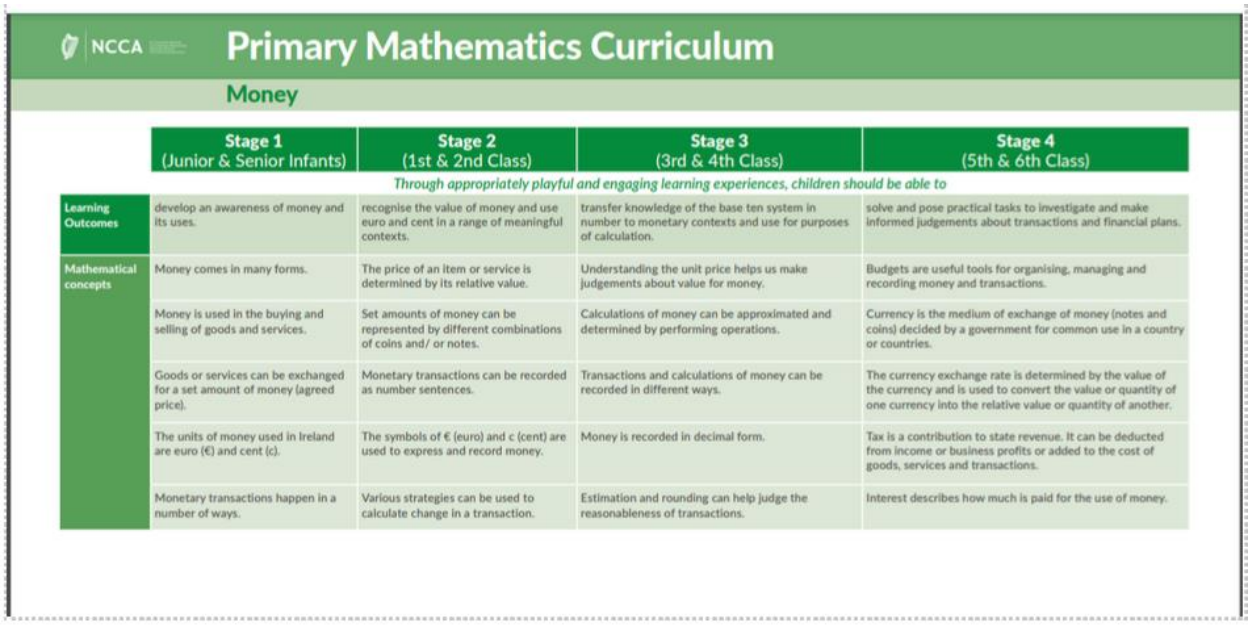
NCCA

Primary Mathematics Curriculum

Time

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	develop a sense of time and its uses.	understand how time is measured, expressed and represented. explore equivalent expressions of time.	compare, approximate and measure time using appropriate units of measurement. identify the relationship between different units and representations of time.	solve and pose practical tasks and problems involving the interpretation and calculation of time.
Mathematical concepts	Events in daily routines can be described and sequenced. A timetable is a useful display to show when things will happen.	Time is measured using universal units; seconds, minutes, hours, days, weeks, months, years and centuries etc. There are distinct relations between these units.	60 is the base of the number system for the conversion of minutes to hours, and seconds to minutes (and vice versa).	Greenwich Mean Time is used as the standard time against which all the other time zones in the world are referenced.
	Time passes consistently.	Units of time measure how long something lasts.	Time is expressed in relation to the hour using minutes or fractional intervals of 60 minutes.	Speed is measured as distance travelled per unit of time.
	Time can be expressed and recorded in a variety of ways.	The hour and minute hands of the analogue clock move clockwise as time passes. The two (sometimes three) hands move at different speeds, according to the units of time they are showing.	Time can be represented using 12-hour or 24-hour formats. The 24-hour format shows the number of hours and minutes elapsed since midnight.	
	Each hour has an area or space on the analogue clock.	Time can be represented in both analogue and digital formats.	Timetables and schedules are tools for managing and organising time.	
	Calendars display days and months and can be used to highlight times of significance.	Weeks are measured in multiples of seven days.	Days are counted from midnight of the previous day.	

Figure A.4. “Measures: Money”



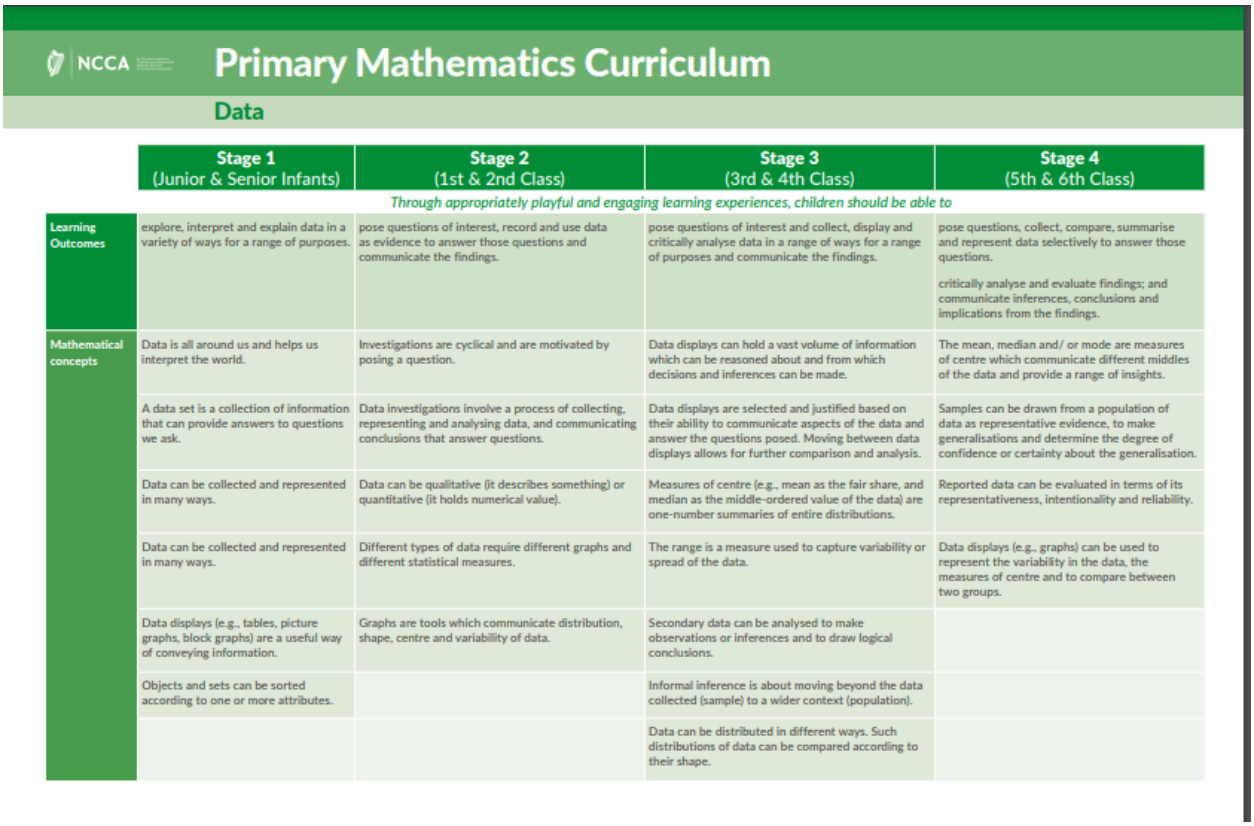
NCCA

Primary Mathematics Curriculum

Money

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	develop an awareness of money and its uses.	recognise the value of money and use euro and cent in a range of meaningful contexts.	transfer knowledge of the base ten system in number to monetary contexts and use for purposes of calculation.	solve and pose practical tasks to investigate and make informed judgements about transactions and financial plans.
Mathematical concepts	Money comes in many forms.	The price of an item or service is determined by its relative value.	Understanding the unit price helps us make judgements about value for money.	Budgets are useful tools for organising, managing and recording money and transactions.
	Money is used in the buying and selling of goods and services.	Set amounts of money can be represented by different combinations of coins and/ or notes.	Calculations of money can be approximated and determined by performing operations.	Currency is the medium of exchange of money (notes and coins) decided by a government for common use in a country or countries.
	Goods or services can be exchanged for a set amount of money (agreed price).	Monetary transactions can be recorded as number sentences.	Transactions and calculations of money can be recorded in different ways.	The currency exchange rate is determined by the value of the currency and is used to convert the value or quantity of one currency into the relative value or quantity of another.
	The units of money used in Ireland are euro (€) and cent (c).	The symbols of € (euro) and c (cent) are used to express and record money.	Money is recorded in decimal form.	Tax is a contribution to state revenue. It can be deducted from income or business profits or added to the cost of goods, services and transactions.
	Monetary transactions happen in a number of ways.	Various strategies can be used to calculate change in a transaction.	Estimation and rounding can help judge the reasonableness of transactions.	Interest describes how much is paid for the use of money.

Figure A.5. ”Data and Chance: Data”



NCCA

Primary Mathematics Curriculum

Data

	Stage 1 (Junior & Senior Infants)	Stage 2 (1st & 2nd Class)	Stage 3 (3rd & 4th Class)	Stage 4 (5th & 6th Class)
	Through appropriately playful and engaging learning experiences, children should be able to			
Learning Outcomes	explore, interpret and explain data in a variety of ways for a range of purposes.	pose questions of interest, record and use data as evidence to answer those questions and communicate the findings.	pose questions of interest and collect, display and critically analyse data in a range of ways for a range of purposes and communicate the findings.	pose questions, collect, compare, summarise and represent data selectively to answer those questions. critically analyse and evaluate findings; and communicate inferences, conclusions and implications from the findings.
Mathematical concepts	Data is all around us and helps us interpret the world.	Investigations are cyclical and are motivated by posing a question.	Data displays can hold a vast volume of information which can be reasoned about and from which decisions and inferences can be made.	The mean, median and/ or mode are measures of centre which communicate different middles of the data and provide a range of insights.
	A data set is a collection of information that can provide answers to questions we ask.	Data investigations involve a process of collecting, representing and analysing data, and communicating conclusions that answer questions.	Data displays are selected and justified based on their ability to communicate aspects of the data and answer the questions posed. Moving between data displays allows for further comparison and analysis.	Samples can be drawn from a population of data as representative evidence, to make generalisations and determine the degree of confidence or certainty about the generalisation.
	Data can be collected and represented in many ways.	Data can be qualitative (it describes something) or quantitative (it holds numerical value).	Measures of centre (e.g., mean as the fair share, and median as the middle-ordered value of the data) are one-number summaries of entire distributions.	Reported data can be evaluated in terms of its representativeness, intentionality and reliability.
	Data can be collected and represented in many ways.	Different types of data require different graphs and different statistical measures.	The range is a measure used to capture variability or spread of the data.	Data displays (e.g., graphs) can be used to represent the variability in the data, the measures of centre and to compare between two groups.
	Data displays (e.g., tables, picture graphs, block graphs) are a useful way of conveying information.	Graphs are tools which communicate distribution, shape, centre and variability of data.	Secondary data can be analysed to make observations or inferences and to draw logical conclusions.	
	Objects and sets can be sorted according to one or more attributes.		Informal inference is about moving beyond the data collected (sample) to a wider context (population).	
			Data can be distributed in different ways. Such distributions of data can be compared according to their shape.	

Appendix B - Examples of other exercises

Figure B.1. "Measures - Measuring" question

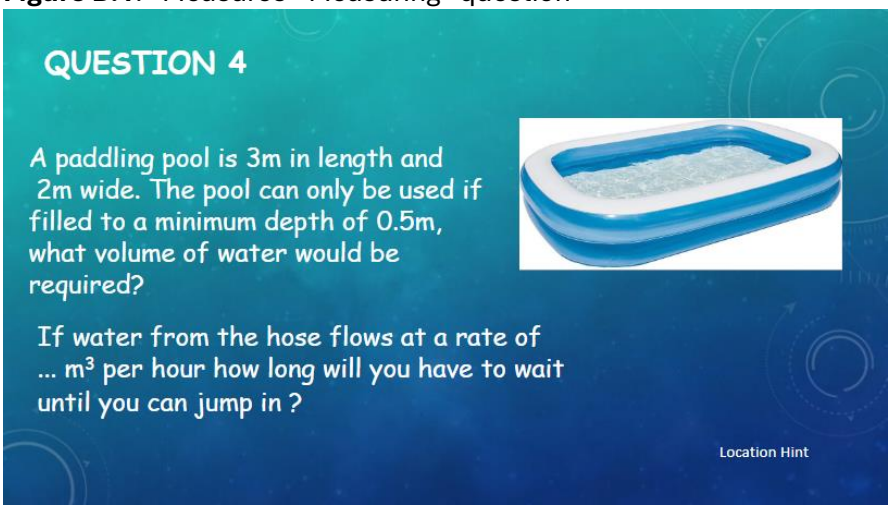


Figure B.2. "Measures - Measuring" question

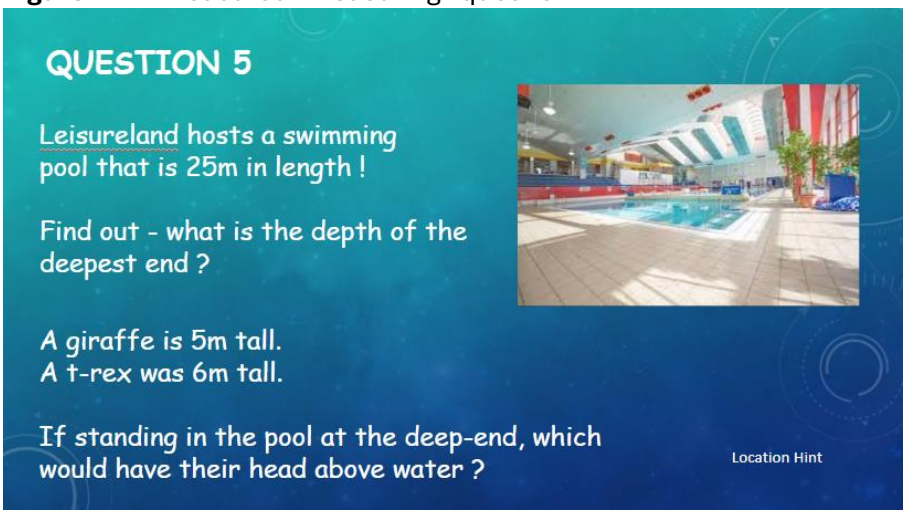


Figure B.3. "Measures: Money" - currency question

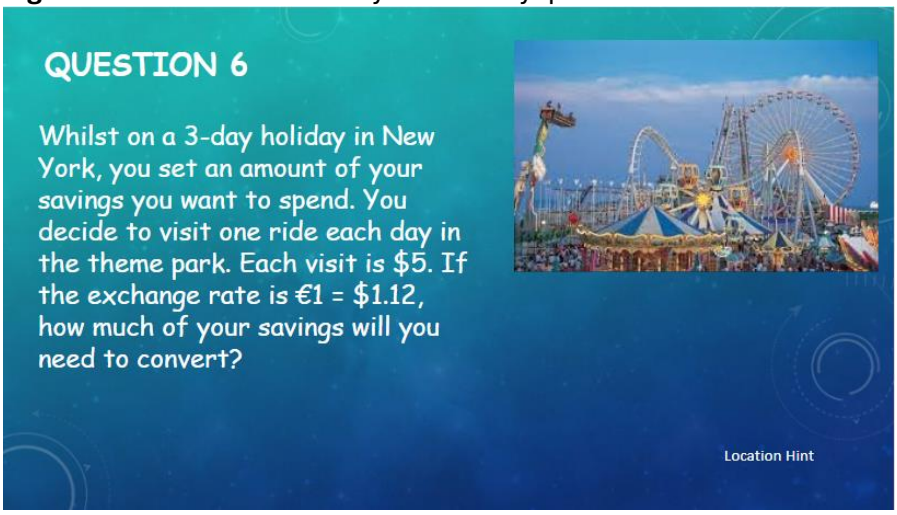
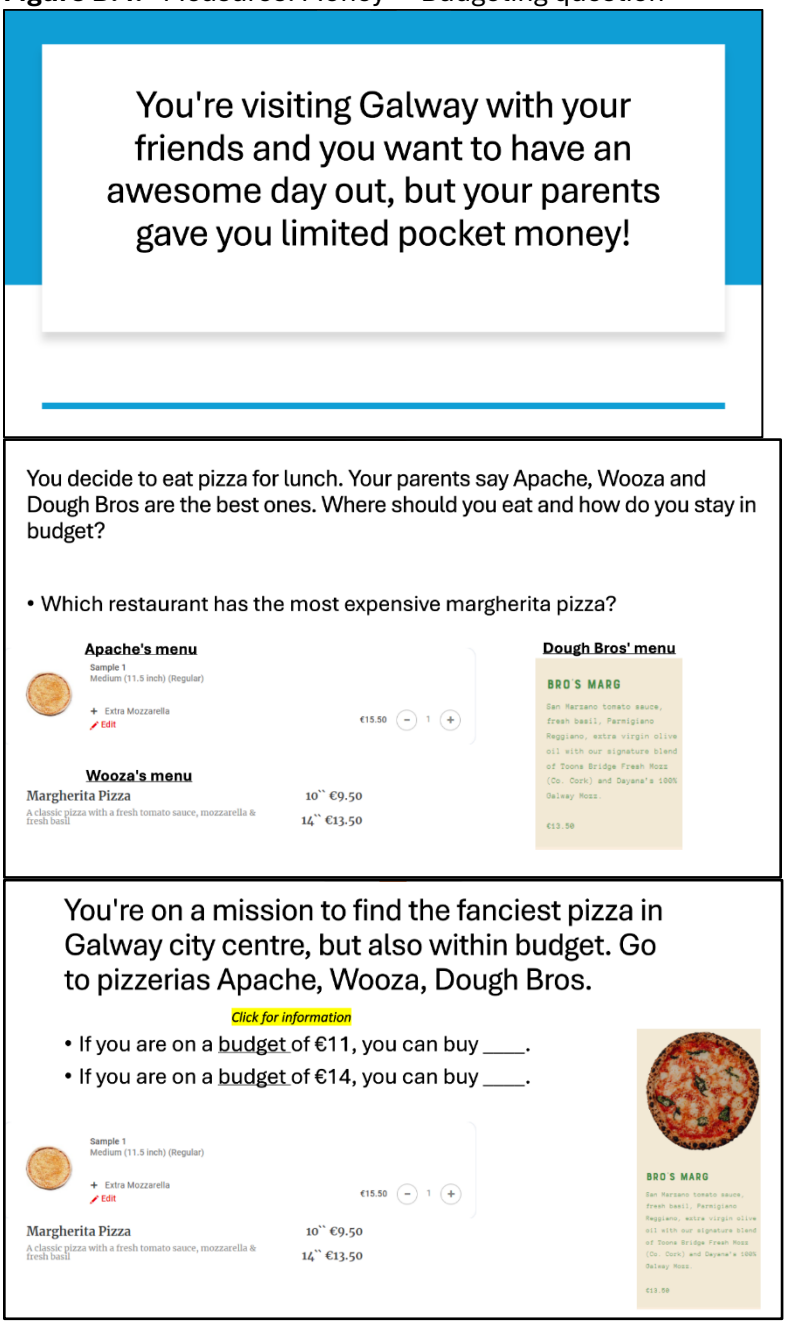


Figure B.4. “Measures: Money” - Budgeting question



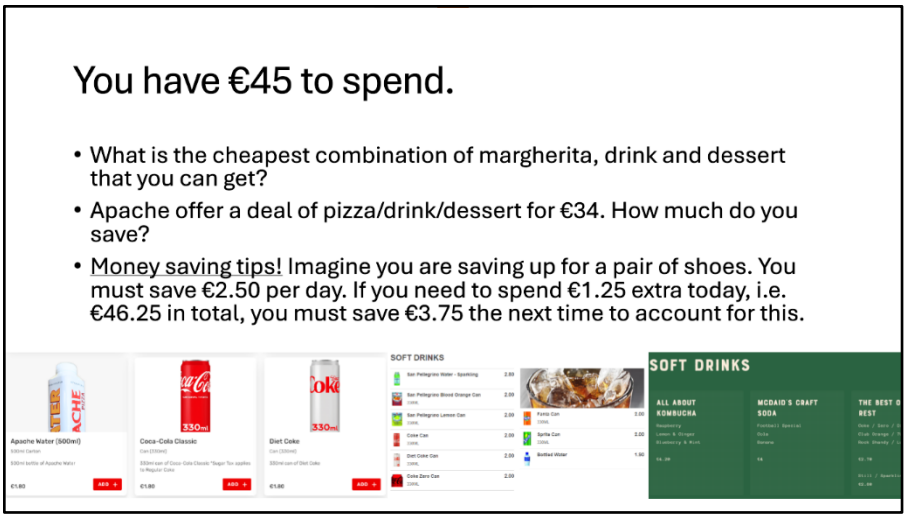


Figure B.5. "Data and Chance – Data" - graph question