Preliminary findings of storytelling in schools as a pre-heatwave intervention to enhance children's behaviour to improve thermal comfort

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Preliminary findings of storytelling in schools as a pre-heatwave intervention to enhance children's behaviour to improve thermal comfort

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ABSTRACT

Younger schoolchildren in particular are at risk of overheating in school due to two key factors. Firstly, children have a preference for lower temperatures than adults, and yet schools are designed and operated using adult thermal preference guidance. Secondly, younger schoolchildren often lack the confidence to change their behaviour in a school setting (remove a jumper, more away from direct sunlight, drink more water etc.) without prompting from the teacher. This paper reports a pilot study of a storytelling approach to enable schoolchildren to enhance their behaviour to improve their thermal comfort. A control: intervention study was undertaken across eight classes, in two schools in Hampshire, UK, with KS1 (national curriculum Key Stage 1, age 6–7) and KS2 (Key Stage 2 age 7–9) children. A new story, "The Hottest Day at School" was developed, where actions to improve thermal comfort were introduced, read by the teacher to children of intervention classes prior to a heatwave. The thermally influenced actions and feelings of schoolchildren were assessed during the heatwave event via a sticker log activity which each child completed. Fisher's exact and Pearson's chi-squared tests indicate statistically significant differences in the actions of KS1 children in particular. Whilst acknowledging the preliminary nature of the findings, the paper suggests that the storytelling approach does enable children to adapt their behaviour to enhance thermal comfort.

1. Introduction

This methodology paper details the preliminary findings of a storytelling approach to support schoolchildren behaviour change to enhance thermal comfort. The approach taken and the limitations that exist to the small current pilot study are discussed, whilst providing an indicative pathway for larger scale, future work. The development and testing of a novel storytelling approach in a classroom as a pre-heatwave intervention with KS1 (national curriculum Key Stage 1, 5–7 year olds) and KS2 schoolchildren (Key Stage 2, 7–11 year olds) is described.

The aim is to support children to make personal behaviour changes (e.g. reducing their number of clothing layers, sit in shade) or environmental behavioural (e.g. opening a window) to enhance their thermal comfort. This is important as younger schoolchildren often do not feel confident to make such changes without the approval of their schoolteacher.

The key objectives of the study are to:

1) Develop a storytelling based intervention to support younger schoolchildren behaviour change during a heatwave event
2) To develop a methodology to assess the above storytelling approach
3) To pilot the storytelling intervention and assessment approach in a school context
4) To provide initial findings from the pilot study on the effectiveness of a storytelling approach to support younger schoolchildren behaviour change during a heatwave event

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1.1. Thermal comfort and adaptive behaviour

Over the last decade, three studies of classroom thermal comfort in the UK by Teli [1], Montazami [2] and Korsavi [3] respectively, have, combined, have assessed nearly 3000 students aged 7–11 years. These studies confirm that children are more sensitive to higher temperatures than adults, and as a result, their comfort temperatures are 2–3° lower than those of adults. Therefore, primary school classrooms in particular, accommodate two types of occupants (i.e. pupil and teacher) with different thermal comfort thresholds, require a suitable approach to maintain comfortable conditions that benefit both the children and the teacher. Uncomfortable classroom temperatures can lead to reduced academic performance, resulting in poor concentration and disruption of classroom discipline, and in more severe cases can lead to health problems and even absenteeism [4,5].

Implementing adaptive behaviour to improve the occupant's state of comfort and quality of environment has been suggested in various studies. The principle here is that if a change occurs to produce discomfort the individual will take actions to restore their state of wellbeing. Fabi et al., [6] explored this topic in the context of window opening behaviour across five groups of factors: physical environmental, contextual, psychological, physiological and social. Specifically, in relation to psychological factors, occupants were seen to satisfy their needs concerning thermal, visual and acoustic comfort. Nicol, Humphreys and Roaf, explained the principles of adaptive comfort and how field studies are used to measure thermal comfort in practice in their book "Adaptive Thermal Comfort: Principles and Practice" [7]. In an office context, Gunay et al. have reviewed adaptive occupant behaviours with a focus on behaviours that adapt the indoor environment, specifically window opening behaviour [8]. Raja et al. assessed the thermal comfort of workers in naturally ventilated office buildings in Oxford and Aberdeen, UK. The results suggest that the use of controls (such as doors, openable windows, blinds, curtains, and fans) is related to thermal sensation and appropriate use of controls is a significant part of adaptive behaviour [9]. Manual window opening behaviour was assessed across 21 offices in Freiburg, Germany by Herkel *et al*. User behaviour reveals a strong correlation between the percentage of open windows and the time of year, outdoor temperature and building occupancy patterns [10].

In their key 2002 paper, Nicol and Humphrey explain the adaptive thermal comfort approach for buildings and the development of the cornerstone adaptive standard and the most likely comfort temperature [11]. Changing occupants' behaviour could be a low-cost approach to enable occupants to achieve their state of comfort, avoiding the need for potentially orders of magnitude more expensive technology based upgrades to a building. Wyon and Holmberg showed via climate chamber observations of schoolchildren (11 years old) that there was a linear relationship between a decrease in clothing level and increasing air temperature in the classroom [12].

There is evidence that the classroom environment is mainly controlled by teachers, who, as discussed above, have a higher overheating threshold and therefore could put children at risk of overheating [3]. The same study confirms that only 17% of students had influence in controlling their classroom environment, with the rest of the changes being influenced by the teacher. In addition, another study highlighted that selecting the types of behaviours (i.e. personal vs environmental) are highly related to a child's social background and their level of confidence [13]. As a result, supporting children (and consequently their teacher) in undertaking personal or environmental behaviour to achieve their state of their comfort, and in doing so, maintain their academic performance and health can be seen as priority.

Singh et al. [14] have extensively reviewed thermal comfort studies in classrooms over the past 50 years. This review shows that students of all ages of education have been assessed to feel comfortable on the cooler side of the thermal sensation scale. This provides further evidence that the thermal comfort scale currently used, based on adults has limitations in a school setting. Secondary school and university students are seen to be in a better position to make day to day adjustments, such as changes in clothing level, open / closing of windows and use of fans. These adjustments playing a significant role in defining the thermal acceptability of natural ventilated classrooms. This wide ranging review provides further evidence of the need to support younger pupils to enhance their adaptive capacity.

Torriani et al. [15] observed that during the winter season neutral, preferred and acceptable temperatures increase with students' age. Adaptive capacities of students were also assessed; it was observed that primary school students were slower in regulating their clothing insulation than older children. Younger children are seen to have lower adaptive capacities to window operations as teachers undertake the majority of window adjustments. Korsavi and Montazami [3] for example, showed that only 16% of primary school students performed window adjustments. Lamberti et al. [16] reviewed thermal comfort issues in educational buildings in terms of current issues and the future way forward. In a primary school context, the adaptive thermal comfort model is seen to predict higher comfort temperatures than the actual values (as per the Singh review [14]) and that social background and behaviour can influence thermal preference. In a secondary school context, students are seen to give more reliable information regarding their thermal state and preference than primary school children. In addition, there has historically been a greater emphasis placed on energy savings rather than learning conditions in school environments.

Aparicio-Ruiz et al. [17] undertook a field study of adaptive thermal comfort in Spanish primary classrooms during the summer season. Various adaptive strategies were assessed via questionnaires with pupils, these included opening windows and doors, adjusting blinds, turning on/off fans, turning on/off the lights. They observed that in terms of adaptive strategies pupils showed a preference towards opening windows and doors over the use of fans (mainly in the afternoon) or changing clothes. A tendency towards opening windows as an adaptive strategy was mainly observed for lower outdoor temperatures, decreasing for higher temperatures. Wyon and Wargocki showed that in the context of mechanically ventilated classrooms, it is changes in temperature that drive window opening behaviour rather than indoor air quality [18]. Together, these published studies highlight that adaptive capacity is lower in younger children, which reinforces the case for approaches such as storytelling to support heatwave behaviour in schools.

1.2. Overheating risks and benchmarks

As the result of high temperature, a child in a classroom can face three types of risks, namely, (i) overheating risk, (ii) cognitive risk and (iii) health risk.

(i) Overheating risk has been part of various school design guidelines since the 1970s. However, the most up to date guidance, Building Bulletin 101 : Guidelines on ventilation, thermal comfort and indoor air quality in schools, published by Department for Education (DfE) only introduces a method to assess if a classroom is at risk of overheating or not [19].
(ii) Cognitive risk, is where temperature is a factor which impacts learning ability in the school context [20,21]. Studies suggest that 26 deg C is a threshold above which cognitive performance drop off with temperature becomes significant [22].
(iii) Health risk, is accounted for through heat strain indices, informed by ISO 7933:2023 and developed in recent research [23] and implemented in calculation tools [24].

To reduce the above risks, there is need to consider first, how overheating would be assessed, followed by understanding the influence of climate change (context) and the UK building school stock (building typology) on occupants' indoor thermal comfort.

Having a suitable method to evaluate the risk of overheating [25,26] would be a first step in reducing the risk of overheating and consequently the cognitive and health risk. Prior to 2012, the risk of overheating for a school building was evaluated based on an approach that considered a fixed temperature as a benchmark. The adaptive approach suggests that fixing a maximum temperature is not appropriate and that the benchmark should reflect outdoor climate at the time, as suggested by the 'adaptive' approach to thermal comfort [7,11]. Montazami and Nicol [27,28] demonstrated that children's thermal perception in a free running building during the cooling seasons is more correlated with the adaptive approach instead of the fixed temperature approach. In addition, this study demonstrated that one of the reasons that schools experience overheating is due to considering a fixed temperature approach in their design rather than an adaptive approach.

For the reason outlined above, on 1 October 2012, the Department for Education (DfE) issued new guidelines for predicting overheating in naturally ventilated schools based on the adaptive temperature limits in European Standard BS EN 15,251 [29]. This guideline became publicly available after a long consultation period in 2018. The guidance considers three criterion, each of which addresses a different aspect of overheating and is detailed in a schools context through building bulletin guidance BB 101 [19].

Criterion 1 - Hours of Exceedance (He): For schools, the number of hours (He) where ΔT (Top -Tcom) is greater than or equal to one degree (K) during the period 1st May to 30th September for the defined hours inclusive shall not be more than 40 h. Where, Top is the operative temperature and Tcom is the comfort temperature.

Criterion 2 – Daily Weighted Exceedance (We): To allow for the severity of overheating the weighted Exceedance (We) shall be less than or equal to 6 in any one day.

Where We = Σhe x wf = (he0×0) + (he1×1) + (he2×2) + (he3×3)

Where the weighting factor wf = 0 if $\Delta T \leq 0$, otherwise wf = ΔT, and hey = time in hours when wf = y

Criterion 3 - Upper Limit Temperature (Tupp): To set an absolute maximum value for the indoor operative temperature the value of ΔT shall not exceed 4K.

As part of the above criterion, 4 types of occupants' expectation have been introduced, in order to calculate the thermal comfort benchmark, of which CATII, which represents normal expectation, is considered when assessing the risk of overheating in both primary and secondary schools [30]. This is despite, as previously stated, several studies over the last decade indicating that primary school children have a lower thermal comfort threshold than adults [1,2,3].

As the result of the using an inappropriate thermal threshold in evaluating the risk of overheating in primary schools, there is a likelihood that the primary schools built based on this guidance would experience overheating from the perspective of schoolchildren. Therefore, the development and assessment of a scalable, behaviour change intervention to enhance thermal comfort amongst primary school children is a priority. This paper reports on a pilot study of such an intervention, based around a story of the hottest week in school.

1.3. Climate change and heatwaves in a UK context

The changing climate of the UK is predicted to result in 'warmer winters and hotter drier summers' [31]. This is alongside an increase in both the frequency and intensity of heatwaves. The Met Office predicts [32] that heatwaves will become normal events for UK summers by 2040, with temperatures exceeding 40 °C every three years under a very high emissions scenario [33]. These are not conditions that the vast majority of the UK building stock have been designed to accommodate. Therefore, there is a need to consider how the context (e.g. schools surrounding greenspace), building factors and occupants can influence the risk of overheating as the result of climate change and heatwaves.

1.4. UK school building stock

The built typology of a school has a strong influence on its overheating risk. Schwartz et al. have modelled the school housing stock in England using an archetype approach to assess both current and future winter heating and summer overheating [34]. Victorian schools which generally have medium to high thermal mass, high ceilings and small levels of glazing represent a low risk built form in terms of overheating [35,36]. In contrast, overglazed, lightweight structures such as SCOLA school buildings, constructed between 1960 and 1975 [37] pose a far greater risk of summer overheating. Single sided ventilation classrooms, with no external shading in low thermal mass buildings can be considered as at high risk of overheating. This risk may be exacerbated by local microclimate effects such as surrounding low albedo flat roofs and the requirement to close windows at night for security.

Fig. 1 shows the distribution of the primary and secondary school stock in England by age, according to the Education Funding Agency [38]. There are a reported 36,935 primary schools with a gross internal floor area of 27 million m^2, compared with 18,874 secondary schools with a gross internal floor area of 23 million m^2. Approximately 50% of the school stock is post 1967 and so a significant proportion of this will have characteristics which will make it vulnerable to overheating. Whilst it is clearly desirable that every classroom can deliver the appropriate environment for learning and thermal comfort, this represents an unprecedented retrofit challenge in terms of scale and capital expenditure.

Council budgets are already under extreme pressure and it is unrealistic to assume that such a retrofit / new school construction programme could be undertaken without direct funding from central government. There has been a surge in councils in the UK issuing section 114 notices [39], which in effect is to declare that the council is bankrupt and unable to balance its books financially without the introduction of cuts to services and reductions in spending. Whilst retrofit measures may be essential for the most vulnerable classrooms, an alternative, low-cost approach such as changing the occupants' behaviour will be required for the majority.

1.5. Enabling behaviour change of occupants through storytelling

The aim of this paper is to test a methodology to promote personal and environmental behaviour change amongst children to achieve a state of comfort. There is an established body of evidence on the use of games and storytelling to change occupants' behaviour toward energy consumption.

Casals et al. [40] developed an interactive online household energy game with a storyline based around an 'Energy Cat' to reduce energy demand. Similarly, Csoknyai et al. [41] developed a mobile platform to enable households to visualise their energy using gamification to stimulate user's behaviour. A key recommendation was that a diversity of games was required to fit the range of public interest in the topic. *Power House* is multiplayer online game developed to encourage home energy behaviour by connecting it to gameplay. The principle here was that a by providing a compelling, social game information can be transformed into a more palatable form [42].

Storytelling in particular, is a well-established approach to engaging with school children [43]. Children are naturally drawn to stories, which they find captivating and this makes learning more enjoyable and memorable. Stories can also spark a child's imagination encouraging creative thinking and problem solving. In many cases, a story may create an emotional connection which helps support deeper learning. A story may also aid memory with facts and key points being easier to recall since these have been introduced in the context of a story. In addition, a story can provide the context for critical thinking where children have the opportunity to analyse the outcomes, events or key decisions that occurred in a story. Paone and Bacher reviewed building occupant behaviour relating to energy efficiency and factors that influence it.

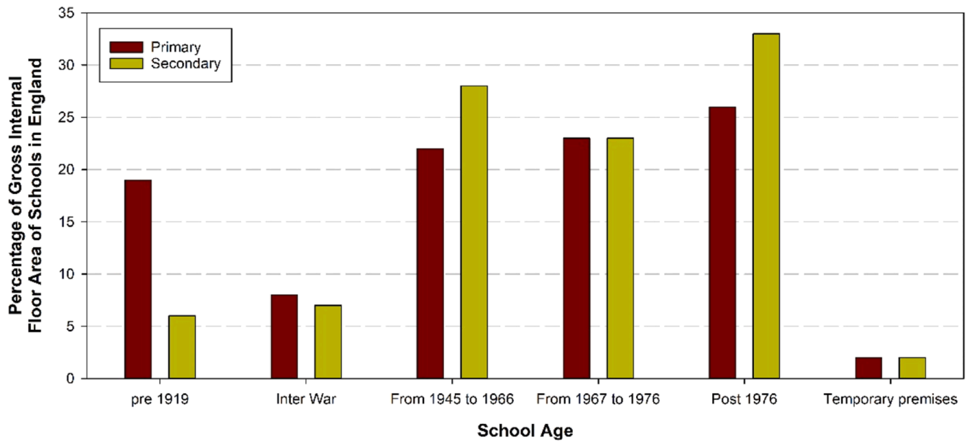

Fig. 1. Distribution of schools in England by age (adapted from [38]).

They highlight that maintain energy efficiency behaviour without compromising thermal comfort remains a challenge. The factors that influence behaviour are seen to be numerous and vaired with gamification a new opportunity to trigger behavioural change [44]. Carol Read's "101 Tips for Teaching Primary Children" guide highlights the importance of maximising the storytelling process, ensuring that stories are exploited for learning and not just for pleasure [45].

Digital storytelling, the practice of using digital media tools to tell stories (combing visuals, animation, interactive elements) is discussed by Rahiem in relation to storytelling in early childhood education. The paper indicates that teachers in the study used digital storytelling because they felt it was more entertaining, captivating, engaging, communicative and theatrical [46]. In addition, digital storytelling is far more easy to scale across a portfolio of schools than a traditional hardcopy story. This is in terms of the both, (i) the ease of distribution of material, and, (ii) the engagement skills required to deliver the story in a powerful way. Rotman used a fairy tale structure to collect over 160 stories from energy experts in over 20 countries. The paper outlines what makes a good story highlighting the importance of a character, plot, choice and a resolution. Simple stories are generally considered more successful [47]. Janda and Topouzi discuss the use of stories as an approach to remake energy policy. They highlight two possible approaches (i) a 'hero story', where society is 'saved' by clever technologies, is inspiring, positive and familiar, or (ii) a 'learning story', where things are not quite as simple as they first seemed [48].

2. Methods

The methods section is divided into four distinct parts. 2.1 details the development of 'The Hottest day at School' story intervention, 2.2 the recruitment and ethics approval process for schools to participate in the pilot study, 2.3 the school children survey methodology and 2.4 the statistical analysis approaches used to assess the schoolchildren survey.

2.1. Developing the story intervention

The research team reviewed story telling literature and consulted with primary schoolteachers across Lower KS2 (ages 7 to 9, year 3 and 4) and Upper KS2 (age 9 to 11, year 5 and 6) as to their opinions regarding the benefit of using storytelling as a means of transferring information to children. The schools' teachers were positive and provided a series of suggestions on language and framing of messaging to help the team to develop a story that captured the students' attention in more depth.

A story, titled "The Hottest Day at School", was developed by two of this paper's co-authors [49]. The story is based on a "history day", in which the protagonist imagines themselves to be a character in history and comes up with five different ways to cope with a heatwave: "The Fan", "The Jumper", "Moving to the Shade", "Opening the Window", "Find a Drink" (see Fig. 2). We would expect at least some of these actions to be available to schoolchildren to act upon, such as remove a jumper, move to the shade or take a drink from their water bottle. School teachers have to balance multiple tasks during their busy school day and providing time for each pupil in a class in relation to their individual thermal comfort would clearly be challenging. Whilst the key messages of the story could be provided by the teacher by simply reminding the class during a heatwave event, we believe the storytelling approach provides a mechanism to support messaging at the individual level which would clearly be valuable.

The story is designed to be used as a teacher led story time class based activity. At the end of the booklet, children then answer questions around the actions that the protagonists in the story undertook to keep cool to reinforce the messaging around actions to take. Here the children were asked to go back through the story and state what each of the five protagonists did to make themselves more comfortable in the challenging circumstances they found themselves in (a Prince in Egypt near the Pyramids, a gladiator in the Coliseum, Maid Marion in Sherwood Forest, a Viking in the North Sea, a cowboy in the Wild West). A PDF of the story can be accessed here [49]. The UK Health Security Agency provides Hot weather and health: guidance and advice for professionals and the public but this is not tailored to schoolchildren [50]. This is a gap which "The Hottest Day at School" in part aims to address.

2.2. School recruitment and ethical approval process

McConnell et al. reported on sample size calculations for educational interventions [51]. For a significance criterion of 0.05 and a statistical power set as 0.80, the sample size calculation approximates to: required sample size = (16/effect size^2). Classroom discussions are reported by McConnell to have an effect size of 0.81, which would correspond to a required sample size (number of pupils) of 24 for equally sized control and intervention classrooms. We therefore recruited schools on the basis of them having two form entry (two classes in the same year group) that would both be prepared to participate in the study. For example, for our KS1 classrooms we actually obtained two equal size classes of $n = 22$, for KS2 we obtained 2 control classes (n = 30 and 27) and 4 intervention classes (n = 27, 27, 28, 32).

The process of recruitment of a school to the study, obtaining of the appropriate permissions and the scheduling of the story intervention and the sticker task assessment is detailed in Fig. 3. The process, story, and assessment tools were assessed and approved through the University of Southampton's Ethics and Research Governance (ergo2.soton.ac.uk, ERGO ref 81907).

HCC contacted the headteachers of potential schools enquiring if they would be interested in participating in the study. The potential

Fig. 2. Storybook cover page and the pages which feature the five action images mentioned in "The Hottest Day at School" storytelling intervention (a. Fan; b. Remove Clothing; c. Move to the Shade; d. Open Window; e. Drink Water). Available to download from [49].

schools pool for this pilot consisted of schools which already had classrooms being monitored by the research team as part of a parallel assessment of longer term overheating patterns in classrooms. If the headteacher gave 'in principle' consent, HCC passed the school details onto the University of Southampton (UoS) who then provided the headteacher with the initial trial information pack (participant information sheet, consent forms etc.). If the headteacher and at least two classroom teachers provided consent the school was added to the study. UoS then briefed teachers regarding the process of the story intervention, the sticker task assessment and the consent process to be followed for schoolchildren. When HCC issued a high temperature (heatwave) alert, the schools sent out to parents / guardians a requirement for them to formally OPT-OUT their child from the heatwave activities that were planned if they did not want their child to undertake them. If no OPT-OUT was received all children were assumed to be able to undertake the tasks. All children were also asked by their teacher if they would like to undertake the sticker task activity before it started. Any OPT-OUT children would have been provided with supported reading in the school in a different location in the school, no children were required to be opted out of the study.

All the schools that participated in this study are located in Hampshire in the South of the UK. This study forms part of a wider collaboration with Hampshire County Council (HCC), the largest Responsible Body in England with over 184,000 children educated in 533 schools. The HCC school estate is diverse, ranging from a 400-year-old listed building, to new schools located in densely populated town centres and schools in the South Downs and New Forest National Parks. The largest building type (approximately 40% of the estate) are 'SCOLA' system buildings constructed between 1960 and 1975 which are particularly at risk of overheating. Hampshire has around 25% of the 'SCOLA' buildings constructed nationally, which are now well beyond their estimated initial design life (HCC, 2023). The overall condition liability HCC is monitoring and managing across its maintained school estate is estimated from surveys to be circa £420million.

HCC approached 10 schools to join this pilot phase intervention. Three schools agreed to participate and were chosen for this phase of the study. At short notice, UoS were made aware that the intervention and assessment dates were not possible for one school due another event and so two schools participated (82 control, 136 intervention children) across six classes.

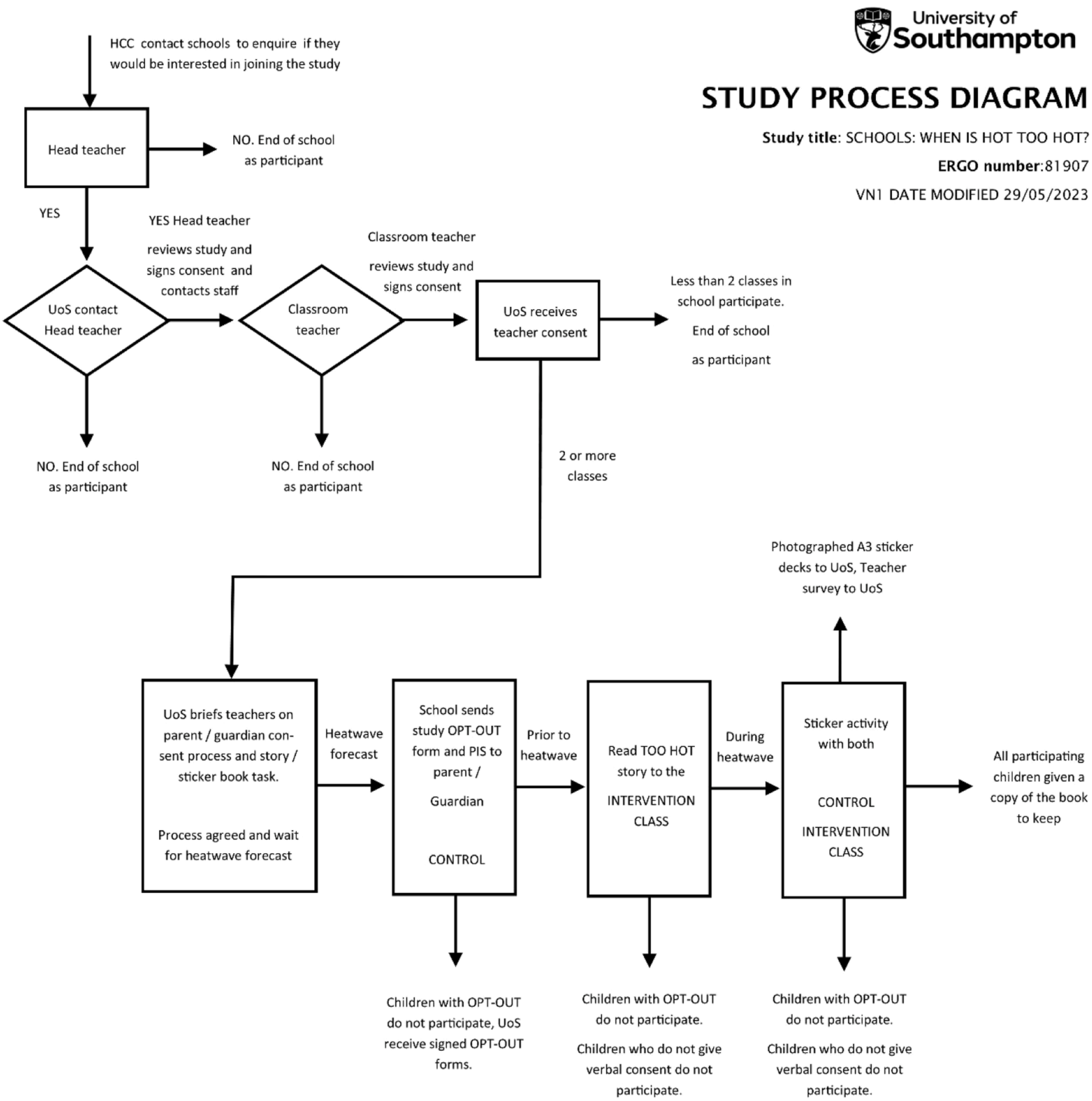

Fig. 3. Storytelling intervention process from school recruitment, multiple consent stages, story intervention and sticker activity assessment.

2.3. *"Sticker task" school children survey*

To assess the impact of the storytelling approach a control : intervention study was undertaken where the story was read in intervention classrooms only. Storytelling is a normal activity for classes and so this type of intervention activity should not be seen as a significant differentiator between the control and intervention classes. A sticker assessment pack was provided to each class to assess the impact of the storytelling technique in changing children's behaviour to enhance comfort. Therefore, the schoolchildren (both control and intervention classroom children) were asked to complete a sticker task-based activity to explain how they felt on the day of the survey (a high temperature, "heatwave" day) and what actions they would like to be able to take for it to be a "better day". A sticker task assessment approach was chosen, as previous work by Teli [52] has shown this to be an excellent engagement method with schoolchildren. The sticker task consisted of four questions: "My day", "My better day", "How I feel at the moment" and "How I wish I felt". Students were given 13 stickers to choose from (consisting of 10 actions and 3 feelings) to describe their "My day" and "My better day", which included the 5 actions mentioned in the storybook as shown in Fig. 4.

The sticker task also includes two 7-point LIKERT scales, in which students could choose a temperature sensation that best matched their feelings to describe "How I feel" and "How I wish I felt". An example, anonymous completed sticker task is shown in Fig. 5.

During the sticker based activity day UoS researchers observed the activities of the children in terms of frequency of drinking water, changes in clothing level (removal of jumper etc.), opening of windows, moving away from seats in direct sunlight, general class attentiveness. The teacher was also asked to reflect via a series of open and closed

Fig. 4. 13 sticker options, 10 actions, 3 feelings that pupils can select from to describe 'My day' and 'My better day'. Sticker designs by Aragon, line art by Chater, LIKERT scales by Teli.

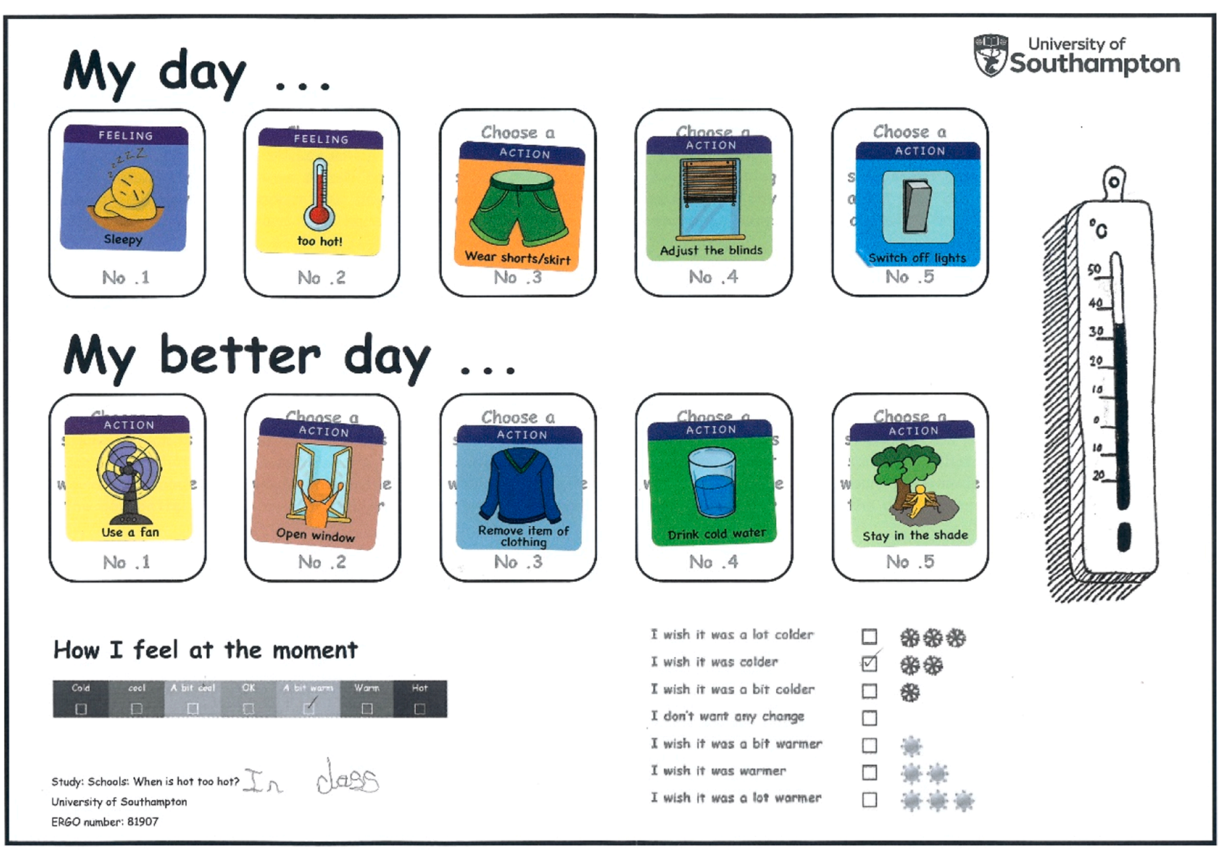

Fig. 5. Example completed sticker task sheet, KS2 Intervention pupil. Sticker designs by Aragon, line art by Chater, LIKERT scales by Teli.

questions on their view of the pupil's experience during the heatwave and general summer and winter conditions. All communication with parents / guardians was undertaken by the school.

2.4. Statistical analysis of schoolchildren survey responses

This study used R [53] to analyse the students' votes on the 5 actions mentioned in the story. As the data is categorical the inferential tests and analysis tools that are used in this study are as follows:

Fisher's exact test: Due to the small amount of data available, this study used a Fisher's exact test to analyse the categorical sticker task [54]. If the calculated p-value is less than 0.05, this indicates that a significant difference exists between the variables, i.e., the intervention had an impact on the students in the intervention group. This 2 × 2 test has one degree of freedom.

Pearson's chi-square test: Where there were more than 2 categories as is the case with the categorical 7-point subjective comfort scale we used Pearson's chi-square test. If the calculated p-value is less than 0.05, this indicates that a significant difference exists between the variables, i.e., the intervention had an impact on the students in the intervention group.

Odds Ratio (OR): In order to quantify the magnitude of this impact, the study also calculates the Odds Ratio (OR) to indicate how likely the intervention group is to make a choice on the action relative to the control group of students.

3. Results

3.1. Running the storytelling intervention and sticker task survey

The UKHSA issued a Yellow heatwave alert for the South East of the UK between 12:00 on 07/07/2023 and 09:00 on the 09/07/2023. This was scored as 7 out of 16 on the combined Impact-Likelihood matrix [55]. The key messaging of this Yellow heatwave alert was as follows "Minor impacts are probable across the health and social care sector, including: increased use of healthcare services by the vulnerable population; increase in risk of mortality amongst vulnerable individuals and increased potential for indoor environments to become very warm." The UKHSA alert was issued to the Emergency Planning Team at HCC at 09:46 on 05/07/2023 who forwarded this to key HCC stakeholders (care homes, school estate support) within an hour of receipt. UoS then decided to proceed with the storytelling intervention across KS1 and KS2 classes in the two schools who ran the storytelling activity on the 5th July and 6th July. Researchers from UoS went to the schools on the morning of Friday 7th July (the heatwave alert day) to undertake the sticker task assessment. The school would follow their standard guidance procedures for all classes with regards to heatwave response regardless of whether a classroom was participating in this pilot study. The "Hottest Day at School" story can therefore be viewed as an intervention in addition to the normal heatwave response of the school.

Table 1 shows the numbers of intervention and controlled cases. The study collected a total of 82 control (1 KS1 class, 2 KS2 classes) and 136 intervention (1 KS1 class, 4 KS2 classes) students' responses. 22 intervention and 22 control students were KS1 and 114 intervention and 60 control students were KS2. The UoS researcher was informed that three students of School B, Intervention 1 class had missed the storytelling and so these three students were classified as an additional control group.

It should be noted that in School B (KS2) there was a mix of ground and first floor classrooms for both the control and intervention classrooms. 33/60 of pupils from the control were on the ground floor (55%), compared with 54/114 (47%) of the intervention classrooms. We used the 7 point Likert thermal comfort scale question 'How I feel at the moment' to assess if the classroom floor level influenced responses. The thermal comfort scale applied in this study is a categorical 7-point subjective comfort scale, so categorical statistical tests are applied. Building on previous study [52], the seven verbal anchors used were 'cold', 'cool', 'a bit cool', 'ok', 'a bit warm', 'warm' and 'hot', shown in Fig. 5 under 'How I feel at the moment?'. As it is often applied in thermal comfort studies, the middle three verbal anchors ('a bit cool', 'ok', 'a bit warm') were grouped into a single category [56]. Table 2 shows the thermal comfort responses of pupils in School B.

Table 1
School and classrooms used for the control vs intervention storytelling.

School	Class	Control, Intervention	Number of students	Classroom description
School A Medium thermal mass school with mixed mode operation (naturally ventilated and mechanical support). Year of construction, 2020 Pupil male, female split 48%, 52%	KS1 (age 6–7)	Control 1 Intervention 1	22 22	Identical, adjacent, mid-block, North facing classrooms, single sided ventilation. Mechanical ventilation support. Ground floor with openable doors to school grounds.
School B SCOLA Type 2, low thermal mass school, naturally ventilated, internal blinds. Mix of single sided and dual aspect ventilation classrooms. Year of construction, 1970 Pupil male, female split 47%, 53%	KS2 (age 7–9)	Control 1 Control 2 Control 3* Intervention 1* Intervention 2 Intervention 3 Intervention 4 *3 students of Intervention 1 class missed the storytelling, so have been classified as an additional control group 3	30 27 3 27 27 28 32	ground floor first floor ground floor ground floor ground floor first floor first floor All classrooms S facing, mid-block (in the middle of the façade), single sided ventilation.

A chi-squared test comparing the thermal responses of the two control classrooms in the KS2 school (one on the ground floor and one on the first floor), shows a statistically significant difference, X^2 (2, $N = 55$) $= 19.2$, $p = 0.000067$. There were 55 responses, 33 on ground floor classroom, 22 from first floor classroom where school children reported feeling hotter than normal. 16 of the first floor responses were +3 on the Likert scale (hot), compared to only 5 on the ground floor. This appears to highlight an extraneous variable in this pilot study of classroom floor location. The relative percentage of control and intervention schoolchildren in the ground and first floor of the KS2 school is however, similar which we believe enables caveated findings to still be drawn. The same chi-squared test applied to the intervention classrooms, does not show a statistical difference between the ground and first floor classrooms but the count of observations have a similar pattern to the control, X^2 (2, $N = 112$) $= 3.60$, $p = 0.165$.

A chi-squared test comparing the thermal responses of the control and intervention classrooms on the ground floor in the KS2 school, does not show a statistically significant difference, X^2 (2, $N = 117$) $= 3.8$, $p = 0.147$. A chi-squared test comparing the thermal responses of the control

Table 2
School B, 7 point Likert thermal comfort scale question 'How I feel at the moment'.
Floor level responses for Control and Intervention classes.

Control / Intervention	Floor	Hot (+3)	Warm (+2)	Bit warm (+1)	Ok (0)	Bit cool (−1)	Cool (−2)	Cold (−3)	Row Total
Control	Ground	5	12	7	8	1	0	0	33
Control	First	16	4	2	0	0	0	0	22
TOTAL		**21**	**16**	**9**	**8**	**1**	**0**	**0**	**55**
Intervention	Ground	21	38	13	11	1	0	0	84
Intervention	First	10	7	6	4	1	0	0	28
TOTAL		**31**	**45**	**19**	**15**	**2**	**0**	**0**	**112**

and intervention classrooms on the first floor in the KS2 school, does however, show a statistically significant difference, X^2 (2, $N = 50$) = 7.8, $p = 0.020$. It would be expected that there would be a greater likelihood of a statistical difference being observed between the control and intervention classrooms on the first floor rather than the ground floor due to the propensity for higher classroom temperatures.

Whilst students were completing the sticker task, the UoS researcher observed and recorded information about the classroom and the students, including the amount of water the students drank, the number of times they used the fan, the clothing the students were wearing and any changes (e.g. removal of a jumper) and the number of windows that were open in the classroom. The observed frequency of drinking from water bottles in the KS1 control classroom was very low (although water bottles were present), two children in the classroom were seen to remove a jumper during the sticker task. No children were wearing jumpers in the KS1 intervention class.

3.2. Classroom environmental conditions during the intervention

Prior to the start of the sticker task assessment, UoS researchers set up an indoor temperature, RH, and CO_2 logger in each classroom. This was usually located near the middle of classroom and was out of direct sunlight. The logger (Extech SD800) specification was as follows: temperature (resolution 0.1 °C, accuracy ±0.8 °C), RH (resolution 0.1 %, accuracy ±4%), CO_2 (resolution 1% ppm, accuracy ±40 ppm), recording data every 30 s to capture the environmental conditions of the schools under the survey. A questionnaire was also administered to the teachers to obtain their reflections on how their students felt during the past year's heatwave periods.

Fig. 6 shows the profile of the outdoor temperature on the day of the survey alongside the seven days prior to the survey for each school. The weighted 7 day average running mean (Trm) and comfort temperature (Tcomf = 0.33 x Trm + 18.8), calculated as per TM52 are also shown [22].

In the case of School A, both classrooms were North facing, with top pivot openable windows and doors which opened onto the predominantly lawned grounds. The UoS researcher set up the datalogger in both classrooms and then undertook the sticker task in the intervention classroom first (~10:50am), followed by the control classroom approximately 30 min later (~11:30am). CO_2 concentrations in the control classrooms were initially measured at ~ 2000 ppm (10:45am), falling to ~ 1100 ppm by 11:30am. This compares to consistent level of ~500 ppm in the intervention classroom. This difference can be attributed to the observed higher number of windows opened in the intervention classroom and doors to the outside has being opened fully. The observed temperature and relative humidity for the duration of the sticker activity task for the control and intervention classrooms of School A are shown in Fig. 7. The higher relative humidity observed in the control classroom is an indication of the lower ventilation rate, which is also reflected in the high CO_2 levels.

For school B, 07/07/2023 was the day of the school's sports day. The school still supported UoS researchers to undertake the sticker task activity despite the added complication of sports day. Whilst the assessment was undertaken in the morning (11:00 – 11:45am) many children were already changed into their PE kit whilst either in their classroom or a main hall (KS2 intervention classes on the ground floor). The sticker activity for one class was assessed outside as they were near their scheduled sports day timeslot (ambient temp 23.9 deg C). Classroom

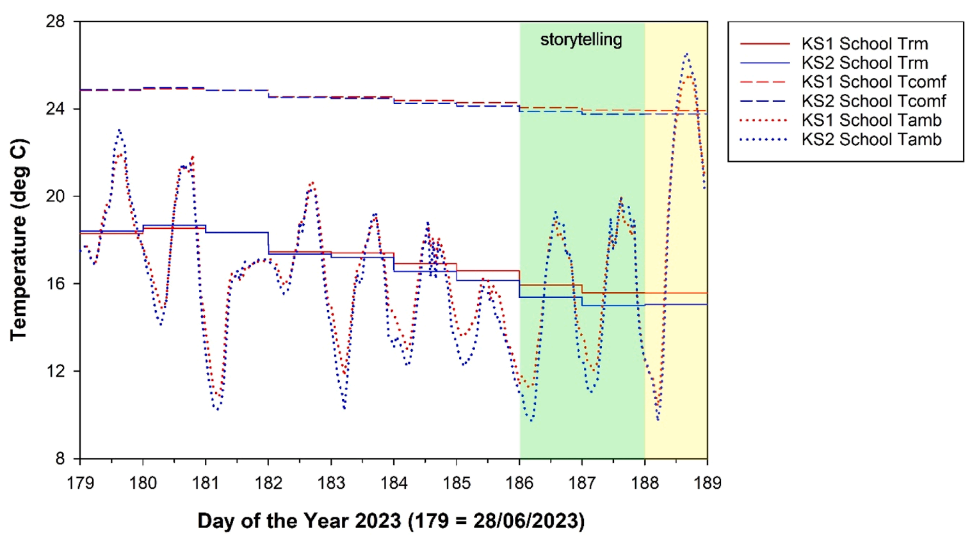

Fig. 6. Ambient temperature (Tamb), Weighted 7 day running mean temperature (Trm) and Adaptive thermal comfort temperature (Tcomf) as defined by CIBSE TM52. High temperature alert issued on day 186, story read to children of intervention classes on either day 186 or 187. Sticker task activity on day 188 for all classes.

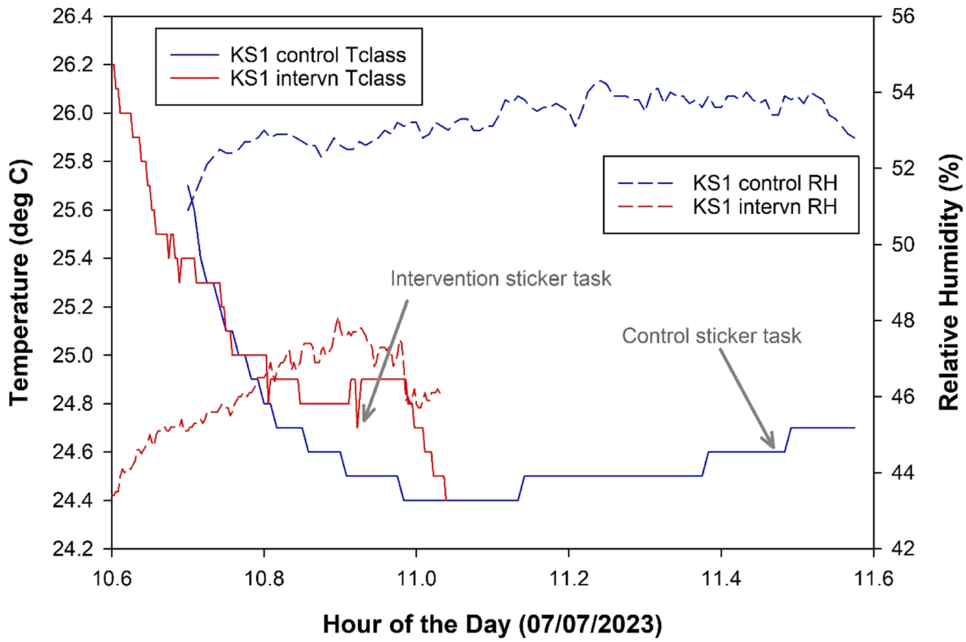

Fig. 7. School A (KS1), Control and intervention classroom temperature (Tclass) and relative humidity (RH) on high temperature day (07/07/2023) during which the sticker task thermal comfort activity was undertaken.

CO_2 measurements ranged between 500 and 1400 ppm with no distinct pattern between control and intervention classrooms. Classroom temperature and RH during the assessment tasks were in the 24.2–25.7 deg C and 48–53% RH range. The thermal sensation votes for the KS2 ground floor intervention classes therefore do not represent the conditions that they may have experienced in their classroom prior to preparing for the sports day. School A (KS1) therefore represents a well controlled, control-intervention experiment. This is not the case for school B (KS2) where the school sports day added further uncertainty to the observations.

3.3. *Comparison of control and intervention classes sticker task responses*

The results are presented in terms of a comparison between the control and intervention groups. This is in terms of "My Day" (MD), how the students felt during the sticker task intervention, and "My Better Day" (MBD), which assesses if students understand how they might be able to improve their thermal comfort. Fig. 8 shows the Odds Ratio for *My Day* (MD) and *My Better Day* (MBD) for the KS1 pupils. In terms of My Day (MD), the 'Stay in the Shade', 'Remove Clothing' and 'Open Window' all have p-values less than 0.05, indicating a statistically significant difference between the control and intervention groups.

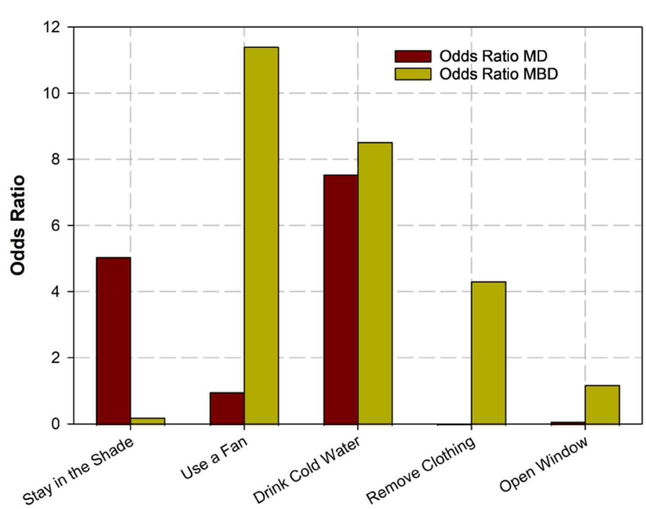

Fig. 8. KS1 children Odds Ratio (shown as a bar) for 5 actions from "The Hottest Day at School" story as calculated from a sticker task survey of control ($n = 21$) and intervention ($n = 21$) KS1 pupil responses.

The results of the Fisher's exact test ($p = 0.045$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Stay in the Shade' for *My Day* (MD). The results of the Fisher's exact test ($p = 0.0$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Remove Clothing' for *My Day* (MD). The results of the Fisher's exact test ($p = 0.002$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Open Window' for *My Day* (MD).

The *My Day* Odds Ratio indicates that intervention pupils are 5 times more likely to have been taking the actions 'Stay in the Shade' and nearly 8 times more likely to have been taking the action 'Drink Cold Water'. The 'Remove Clothing' and 'Open window' actions have very low Odds Ratio's, this is probably because these actions had already been taken based on the observations of the classroom and the level of pupil clothing.

The *My Better Day* p-value is statistically significant for fan use (this was not an option available to children in the actual classes), stay in shade and drink cold water. The results of the Fisher's exact test ($p = 0.021$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Use a Fan' for My Better Day (MBD). The results of the Fisher's exact test ($p = 0.033$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Stay in Shade' for My Better Day (MBD). The results of the Fisher's exact test ($p = 0.022$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Drink Cold water' for My Better Day (MBD).

The *My Better Day* Odds Ratio indicates that KS1 intervention pupils are almost 12 times more likely to take the action 'Use a Fan', 8 times more likely to take the action 'Drink Cold Water' and 4 times more likely to 'Remove Clothing' than the control group.

Fig. 9 shows the corresponding Odds Ratio for *My Day* (MD) and *My*

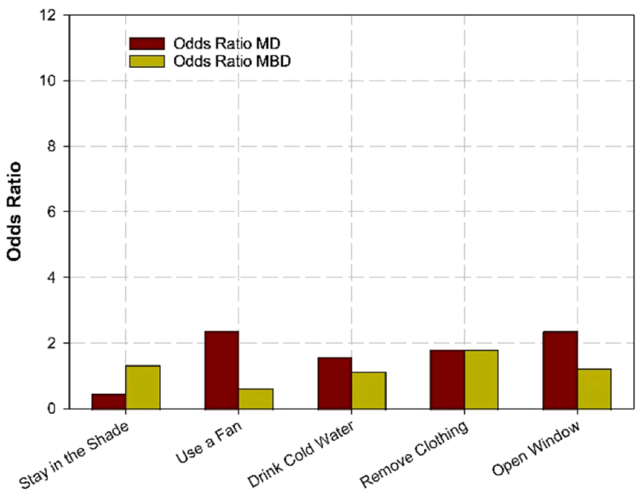

Fig. 9. KS2 children, Odds Ratio for 5 actions from "The Hottest Day at School" story as calculated from a sticker task survey of control (n = 55) and intervention (n = 107) KS2 pupil responses.

Better Bay (MBD) for the KS2 pupils. In terms of My Day (MD), the 'Stay in the Shade', 'Use a Fan' and 'Open Window' all have p-values less than 0.05, indicating a statistically significant difference between the control and intervention groups. The results of the Fisher's exact test ($p = 0.042$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Stay in the Shade' for My Day (MD). The results of the Fisher's exact test ($p = 0.023$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Use a Fan' for My Day (MD). The results of the Fisher's exact test ($p = 0.031$) indicates a significant association between a classroom being read the intervention story and a child reporting the action 'Open Window' for My Day (MD).

The *My Day* Odds Ratio indicates that intervention pupils are more than twice as likely to take the actions 'Use a Fan' and 'Open Window'. The KS2 *My Better Day* p-value is not statistically significant for any of the actions. The KS2 *My Better Day* Odds Ratio is less than twice for all of the actions.

Pupils were asked to report their current (when the sticker task was undertaken) and desired level of thermal comfort using the 7 point ASHRAE scale. (+3=hot, + 2=warm, +1=slightly warm, 0=neutral, −1=slightly cool, −2=cool, −3=cold). Fig. 10 shows a box plot of the stated thermal preferences (TSV, Thermal Sensation Vote) of the four classroom groups (KS1, KS2, control and intervention). The temperature measured in the classroom by the SD800 datalogger is taken to be the operative temperature (average of radiative and ambient temperature) as the classrooms are low to medium thermal mass. In this context, previous work by Teli [57] has shown the operative and ambient temperatures to be very similar in such a school context. Teli compared 565 sets of simultaneous measurements of air and radiant temperature for various outdoor weather conditions collected from three schools in Southampton to assess the relationship between the measured air temperature (Ta) and calculated operative temperature (Top). The average difference between Top and Ta for a newly built school was −0.1 (σ=0.1), for a medium-weight building 0.2 (σ=0.2) and for a light-weight building (school C) it was 0.4 (σ=0.3). All of these values are lower than the manufacturer-stated accuracy of the air temperature sensor used here and so monitored air temperatures were used without any correction.

Fig. 10 shows a bubble plot of the Thermal Sensation Vote (TSV) of schoolchildren across the four classroom groups. The Predicted Mean Vote (PMV) is calculated based on the temperature (classrooms ranged between 23.9–25.5 deg C), clothing (0.50 clo), RH (46–53%) and airflow speed (0.1 m/s assumed) measured in each classroom and is shown as a purple triangle. It is interesting to note that the KS1 control group has far more responses in the +3 band (hot) than any of the other three groups. The PMV in both the KS1 and KS2 control classes are very similar, which

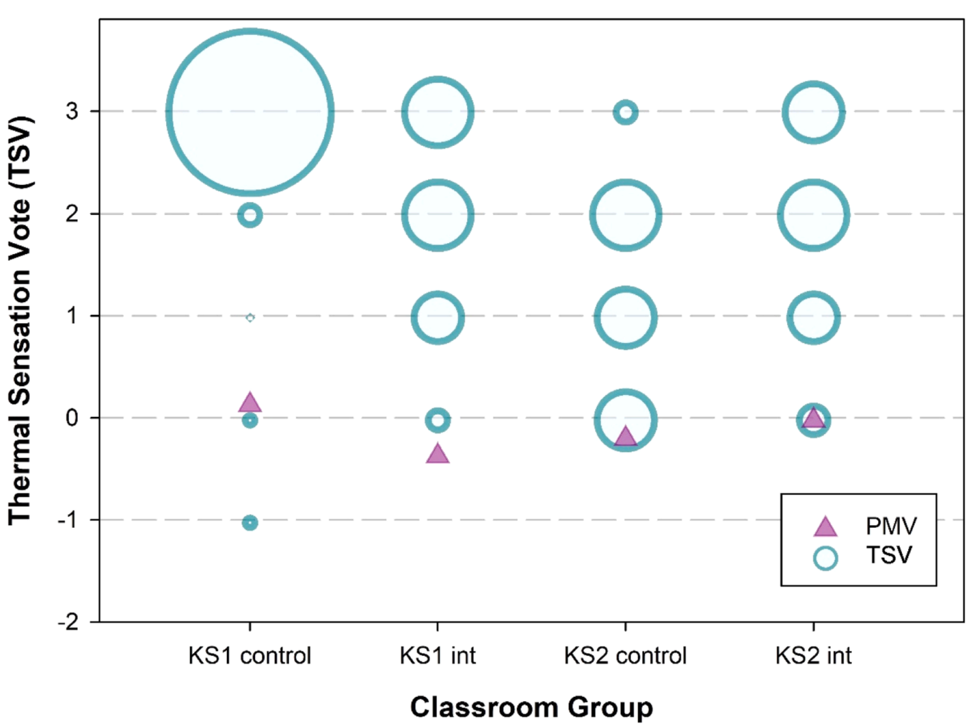

Fig. 10. Frequency bubble plot of the stated thermal comfort preference (TSV, Thermal Sensation Vote) of the four classroom groups (KS1, KS2, control and intervention). Predicted Mean Vote (PMV) is shown as a purple triangle, calculated from classroom environmental conditions calculated using the CBE Thermal Comfort Tool [58]. Diameter of bubble proportional to the number of responses.
TSV scale: +3=hot, + 2=warm, +1=slightly warm, 0=neutral, −1=slightly cool, −2=cool, −3=cold.

Table 3
School A, 7 point Likert thermal comfort scale question ‘How I feel at the moment’. Control and Intervention classes.

Control / Intervention	Hot (+3)	Warm (+2)	Bit warm (+1)	Ok (0)	Bit cool (−1)	Cool (−2)	Cold (−3)	Row Total
Control	17	2	0	1	1	0	0	21
Intervention	7	7	5	2	0	0	0	21
TOTAL	**24**	**9**	**5**	**3**	**1**	**0**	**0**	**42**

Table 4
School A, 7 point Likert thermal comfort scale question ‘How I feel at the moment’. Control and Intervention classes. “Hot (+3)” response count compared to sum of all other responses “Other(+2..−3)”.

Control / Intervention	Hot (+3)	Other (+2..−3)	Row Total
Control	17	4	21
Intervention	7	14	21
TOTAL	**24**	**18**	**42**

means that the TSV vote distribution would be expected to be similar if the cohorts had the same thermal sensation. This does perhaps indicate that younger children (KS1 control compared to KS2 control classes) have a lower thermal preference and provides a further indication of the impact of storytelling at KS1. A clear caveat here when comparing KS1 and KS2 in this pilot study is that this is across two different schools.

A Fisher exact test compared the KS1 control and intervention in terms of the number of children who reported a TSV vote of +3 (hot) as their TSV vote. The survey responses (count of number of students) is shown in Table 3. Responses which were not, “Hot, +3″, were aggregated together to produce the 2 × 2 table for the Fischer exact test as shown in Table 4. This approach was taken as we are concerned here specifically with the number of students who report being Hot, the highest level of thermal discomfort in the summer term. 17 or 21 responses in the KS1 control reported a TSV of +3, compared to 7 of 21 for the intervention. The results of the Fisher’s exact test ($p = 0.0044$) indicate a significant difference between a classroom being read the intervention story and a control classroom in the number of children reporting feeling hot in the classroom. This suggests an association between the intervention and a reduction in the number of children feeling hot.

A Pearson’s chi squared test was also undertaken where our three categories were Hot (+3), Warm (+2) and the combined (bit warm, ok, bit cool) as per the statistical analysis undertaken for the School B ground, first floor comparison reported in Section 3.1. The result is consistent with the Fisher’s exact test, we observe a statistically significant difference, X^2 (2, $N = 42$) = 9.7, $p = 0.007742$.

Two of the four KS2 intervention groups undertook the sticker task activity in the main hall / waiting outside to participate in the school sports day (and changed into PE kit). The calculated PMV here applies the PE clothing level and the temperature in the main hall / ambient.

4. Discussion

In this pilot study, students’ level of thermal discomfort appears to be much higher than that calculated by the PMV model, which indicates that students are indeed experiencing heat problems in the current classroom conditions. This is consistent with the findings of studies by Teli, Montazami and Korsavi where younger children were assessed as having a lower thermal comfort temperature than adults [1–3].

Teaching staff completed a survey providing their perspective of thermal comfort in their classrooms during the academic year. This survey provided further evidence regarding overheating classrooms in the summer. The majority of teachers stated that they experienced high temperatures ‘very often’ in their classrooms, for durations of approximately a week at a time. The variability of temperatures is classrooms during a summer day was highlighted by many teachers. In terms of reasons behind overheating, reported high occupancy (large class sizes), alongside lack of ventilation / airflow were common themes.

This study suggests that storytelling as an intervention had a significant effect on KS1 pupils’ actions in response to the hot day at school, and also had some effect on KS2 pupils, but this effect was limited in comparison to KS1 subjects. The small scale of this pilot study, which is complicated by the use of 2 schools and classrooms across two floors means the authors feel that findings should be taken as indicative at this point. Pupils’ actions and some environmental factors in the classroom (e.g. opening windows, using fans) may have been influenced by the teacher to some extent, but KS1 pupils still demonstrated memory and understanding of the behaviours mentioned in the intervention. The use of the storybook as a thermal comfort education material was also endorsed by the teachers who participated in this study. It was seen as a popular way for the engage with pupils, which further suggests that the intervention materials used in this experiment can be effective in changing pupils’ behaviours when coping with summer overheating in the classroom. The intervention storybook used in this experiment could be considered for use with students across the UK to enhance students’ coping with summer overheating and reduce the health impacts associated with summer heat.

5. Conclusions

Review studies have shown that in relation to thermal comfort, younger school children have lower adaptive capacity [14–16]. They lack the knowledge / confidence to take action, such as to change their clothing level or open a window. The storybook material used in this pilot study appears to be an effective and liked intervention by KS1 pupils to change pupils’ behaviour in response to the high temperatures in school. Therefore, a larger scale study is being established with more schools involved. This will further explore the impact of the storytelling intervention method on pupils of different ages and the factors that may influence its effectiveness with a greater level of statistical rigour. A larger sample would also control for potential extraneous variables such as the style of reading of the story by the teacher which have not been considered in this pilot.

The scope of the experiment reported here was limited due to the single day duration of the July 2023 high temperatures. In the future, experiments on thermal comfort interventions with students, will incorporate longer, heatwave periods to obtain more varied data on students’ actions to cope with overheating. To achieve a more scalable intervention, with the added benefit of consistency of delivery, the story has been converted into an animated video which can be played to schoolchildren when a heatwave warning is issued. The study will in future assess schools where there is a three form entry (3 classes for each year group). This will enable a control: intervention approach where both the physical story book approach detailed in this paper and the animated video equivalent can be applied in the same context against a control class. This will provide valuable insight into the relative performance of the two approaches and how storytelling in this context could scale to a national level intervention.

Fig. 11 shows examples of revisions to the hardcopy book with enhanced artwork and the corresponding frames from the professionally narrated, animated video story (12 min duration) which has been produced. Promoting a storytelling technique as a method that encourages

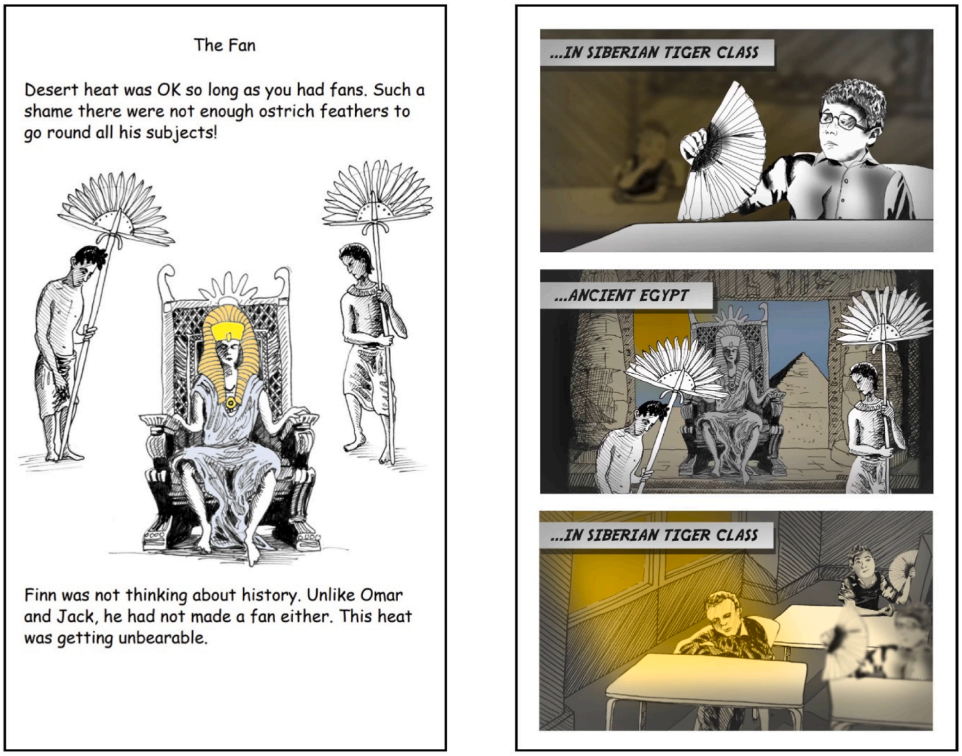

Fig. 11. LEFT revised hardcopy story, RIGHT new animated video story of the Hottest Day at School for future larger scale deployment. Artwork by Mike Chater / BigPawAnimation [61].

children to adopt suitable behaviour to enhance their thermal comfort can contribute to the National Climate Education Action Plan 2021 [59] which is part of the wider government initiative on 'Sustainability and climate change: a strategy for education and children's services systems' [60].

CRediT authorship contribution statement

Patrick James: Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Investigation. **Yu Gao:** Writing – review & editing, Writing – original draft, Investigation, Formal analysis. **Michael Chater:** Resources, Methodology, Conceptualization. **Azadeh Montazami:** Writing – review & editing, Resources, Methodology, Conceptualization. **Stephanie Gauthier:** Methodology, Investigation, Conceptualization. **Phillip Turner:** Methodology, Data curation, Conceptualization. **Victoria Aragon:** Investigation, Data curation. **Despoina Teli:** Writing – review & editing, Conceptualization. **Trinabh Mittal:** Investigation. **Massimiliano Manfren:** Writing – review & editing, Formal analysis.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: PAB James reports financial support was provided by Hampshire County Council. Sustainability Design Advisor- Operational Carbon and Engineering, Department for Education, Azadeh Montazami If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Data availability

The authors do not have permission to share data.

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