Journal of Risk Research

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rjrr20

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To cite this article: Sarah M. Duckett, Elizabeth A. C. Rushton & Ragnar Löfstedt (06 May 2025): Where is risk education? Exploring risk education in secondary schools in England, Journal of Risk Research, DOI: 10.1080/13669877.2025.2496225

To link to this article: https://doi.org/10.1080/13669877.2025.2496225

Published online: 06 May 2025.

JOURNAL OF RISK RESEARCH
https://doi.org/10.1080/13669877.2025.2496225

Routledge
Taylor & Francis Group

Where is risk education? Exploring risk education in secondary schools in England

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ABSTRACT

Risk researchers have asserted that risk education in secondary schools is minimal, if it exists at all. This study shows that some aspects of risk are taught as part of the National Curriculum in England. As risk science has developed, many of its proponents have recognised the importance of ensuring that all students in secondary schools are exposed to risk concepts and thinking. In the education field, risk education is seen as important but in competition with many other subject areas in the curriculum. This study uses text analysis and semi-structured expert interviews with a sample of teachers and teacher-educators, and other experts in education to contrast official education policies with their experiences in the field. It identifies how risk education is conceptualised by this sample of educators and where in the curriculum risk concepts are principally taught. Assessment, legitimacy, and resources are barriers to wider adoption of risk education in secondary schools in England. It is essential that risk experts and education experts work together to further integrate risk education into the curriculum and teaching practice.

ARTICLE HISTORY
Received 29 May 2024
Accepted 6 April 2025

KEYWORDS
Risk education; education experts; risk science; risk literacy; secondary schools; expert elicitation

1. Introduction

Over the last five decades, there has been a significant increase internationally in recommendations to include risk education in school curricula. These include recommendations in technical and scientific reports such as the 'Lofstedt report' (Lofstedt 2011), and *Technical assistance in the field of risk communication* by the European Food Safety Authority (EFSA) (2021). Such recommendations are also implicit in academic papers such as those by Slovic, Fischhoff, and Lichtenstein (1980), Aven and van Kessenich (2020) and van Kessenich and Geerts (2017). Briscoe (1992) argued that,

> The almost total lack of risk teaching in high school consumer education classes and the minute progress in developing national risk standards are a serious indictment of the government and scientific and educational communities.

Earlier endeavours, such as the curriculum development initiated by Daniel Kahneman and Seymour Fox in the 1970s for the Israeli Ministry of Education, underscored the importance of integrating judgement and decision-making skills into educational frameworks (Kahneman 2012b;

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Beyth-Marom and Dekel 1983; Beyth-Marom and Dekel 1985). Despite initial enthusiasm, practical implementation challenges hindered widespread adoption of these initiatives (Kahneman 2012a). Subsequent efforts, such as the trialling of decision-making courses like the GOFER program in Australia in 1988, further underscored the complexities inherent in assessing the efficacy of such educational interventions (Mann, Harmoni, and Power 1991; Mann et al. 1988; Beyth-Marom et al. 2012).

Including risk education in schools is frequently associated with calls for a broader societal engagement with risk, from organisations such as the Health and Safety Executive (2000); Institute for Occupational Safety and Health (IOSH) (2010) and the European Food Safety Authority (EFSA) (2021). In a report on *Risk literacy and the public: MMR, air pollution and mobile phones* for the UK Department of Health, Petts et al. (2003) stated,

> Education has an important role to play in raising risk literacy. Teaching 'pure' science needs to be complemented by understanding of risk and developing competencies for dealing with risk in adult life.

The Institute for Occupational Safety and Health (IOSH) (2010) advocated integrating health and safety into the basic education system to foster a 'risk intelligent society'. Lofstedt (2011) supported this initiative and called for a broader societal discussion on risk, recommending the inclusion of risk assessment in high school science curricula. In a recent report, the EFSA (2021) also underscored the importance of integrating risk communication and hazard analysis into educational curricula.

However, the development of educational materials and approaches, as exemplified by works like Gage and Spiegelhalter's (2016) 'Teaching Probability,' emphasize the practical relevance of probability and uncertainty in real-world scenarios, advocating for a nuanced understanding of risk beyond mathematical formulations. They demonstrate that probability – a key component of risk – is already in the school curriculum. This raises the question of what other components are in the curriculum already, potentially scattered across different subjects? Are the calls for risk education based on the mistaken assumption that it is entirely absent from current curricula?

Given the piecemeal development of risk education efforts, as demonstrated above, the perception has arisen that little or no risk education is undertaken in schools. In the face of this conflicting evidence, we need to better understand the extent to which risk concepts and theories are currently taught in secondary schools. It is this gap that this research addresses, ensuring that future risk education policy takes into account the policy and practice of teachers and educational authorities.

We examine how risk education is and could be included as part of formal schooling. We explore the ways in which risk education is currently understood, taught and valued in secondary schools in England through the experiences of teachers and teacher educators. Whilst risk experts advocate for the importance of school-based risk education (Duckett, Löfstedt, and Rushton 2024; see also Lofstedt 2011; Aven and van Kessenich 2020), no previous study has sought to understand risk education across the curriculum, examining multiple subjects, through the experiences of teacher educators and teachers themselves. This article centres on the research questions*: What should risk education look like in schools? To what extent are risk concepts and theories taught in secondary schools in England? How is risk taught and assessed in schools? Are there any barriers to implementing risk in the curriculum?*

We begin by exploring the ways risk education have been conceptualised in varied literatures including the field of risk analysis and in educational research including mathematics education and science education.

2. Towards a conceptualisation of risk education

As outlined above, there have been consistent calls for risk education to be a more visible part of secondary school education. Yet, as an emergent field, there is no agreed definition of risk

education. In 2018, The Society for Risk Analysis (SRA) outlined the core subjects which were seen as essential for the field of risk analysis, aiming to establish the knowledge domains of risk analysis as a science, foster discussion and guide educational programmes at different levels (Aven et al. 2018). These core subject areas identified for risk analysis presented in the report are summarised in Table 1. Through this report, the SRA outline a comprehensive framework for risk analysis, including the fundamental concepts, principles and methodologies essential for understanding and managing risk. These core subjects include definitions of risk, risk metrics and types of uncertainties. Also included are the principles and methods for risk assessment, issues related to risk perception and communication. Finally, strategies and activities for risk management and governance and practical applications for solving real-world risk problems and issues are also identified as fundamental parts of risk analysis (Aven et al. 2018; Table 1).

Aven et al. (2018) note that the core subjects the report identified (Table 1) are those suitable for varied educational levels, including secondary schools, higher education programmes and professional learning courses. Necessarily, the educational level will influence what is considered central to the field (Aven et al. 2018). To summarise, the SRA report conceptualises risk education as including fundamental disciplinary knowledge (e.g. principles and definitions of risk), technical knowledge (e.g. risk assessment) and applied or contextualised knowledge (e.g. solving real risk problems and issues). We understand these as distinct but also integrated components which inform a conceptualisation of risk education.

In the wider research literature, scholars have conceptualised risk education as drawing on concepts and fundamental ideas of mathematics, science and geography and therefore realised through teaching these subjects, including in schools. For example, Christensen (2009) identifies the key components of probability, uncertainty and judgement and decision-making in their conceptualisation of risk education. Probability is regularly recommended as part of risk teaching in the mathematics curriculum (Radakovic and Chernoff 2020) and hen considering the teaching of risk in high school mathematics, Radakovic (2015, 326) states that 'decision making about risk is an interplay between quantitative reasoning, experiences, values, beliefs, and content knowledge'. Probability is often taught as abstract concepts, however Pratt et al. (2011) recommend including context and risk-based reasoning in the subject to support making risk-based decisions in everyday life. Consistent with the SRA (2019) conceptualisation of risk analysis, the conceptualisation of risk education through mathematics includes both fundamental concepts (e.g. probability, uncertainty) but also applied or contextualised knowledge (e.g. decision making).

In science education, risk is understood to include uncertainty, risk perception and judgement and decision-making (Schenk et al., 2019) and scholars have argued that these aspects

Table 1. Core subject areas of the field of risk analysis as identified by Aven et al. (2018).

Core subject	Description	Key topics
Fundamentals	Basic concepts and principles of risk analysis, including ways of representing and expressing uncertainties.	Definitions of risk, risk metrics, probability models, and types of uncertainties.
Risk Assessment	Principles, approaches and methods for identifying and analysing risk sources, threats, and consequences.	Stages and processes of risk assessment, qualitative and quantitative methods, and evaluation of risk.
Risk Perception and Communication	Issues related to how risk is perceived and communicated, including social and cultural factors.	Determinants of perceived risk, communication models and theories, and the role of media in relation to risk.
Risk Management and Governance	Measures and activities for managing and governing risk, including decision-making and policy-making.	Risk management strategies, decision-making frameworks, and regulatory issues.
Solving Real Risk Problems and Issues	Practical application of theories and methods to solve real-world risk problems and issues.	Case studies and practical examples from various fields such as engineering, public health, and finance.

of risk should be included in science education as part of what is termed 'socio-scientific issues' (SSIs) (Schenk et al., 2021). SSIs are considered integral to advancing science literacy and are regularly included in science education (Zeidler and Nichols 2009). SSIs involve an intersection of scientific knowledge with moral or social issues that encourage students to engage in decision-making, debates, and discussion (Herman, Clough, and Rao 2022; Zeidler and Nichols 2009). SSIs are also suggested by Christensen (2009) as a place for the teaching of risk in the science curriculum, however the author acknowledges the controversial nature of SSIs in education when their use entails the goal of science education for citizenship. As with mathematics education, ideas of risk in science education combine fundamental or disciplinary knowledge (e.g. uncertainty, risk perception) with contextual knowledge, including moral or social issues. Therefore, across these fields of risk analysis, mathematics education and science education, we can identify some overlapping conceptualisations of what constitutes risk education.

As well as the subjects of mathematics and science, ideas of risk are included in school subjects of geography and Personal, Social, Health and Economic (PSHE) education. For example, the school subject of geography includes teaching about natural hazards and disasters and the related field of Disaster Risk Reduction (DRR) education frequently includes teaching about resilience and mitigation strategies in relation to local natural hazards and disasters (Kagawa and Selby 2012). Recently, global and societal hazards have started to be included in DRR education, with specific calls for decision-making and risk communication to be included as part of the DRR teaching (Shaw, Sakurai, and Oikawa 2021). Bardsley (2017) suggests that the millennials and younger generations are likely to face more risks than previous generations and that secondary school Geography is the place to prepare them for those real-life risks. Bardsley (2017) surveyed teachers to determine what risks they felt students would likely encounter in their lives, and teacher perspectives on a risk curriculum, finding that teachers were cautiously enthusiastic about the idea of teaching risk. Turning to Personal, Social, Health, and Economic (PSHE) education in England, this school subject addresses some of the real-life risks young people face, such as drug and alcohol use, and sex education. A study by Davies and Matley (2020) examined teacher perspectives on the content of PSHE and found that teachers were not particularly confident in teaching on the PSHE topics. Therefore, across school geography and PSHE, ideas of risk focus on themes of hazards and other real-life risks. This is consistent with Wilson's (1990) ideas of the role of schools in teaching risk, and therefore conceptualisations of risk education, which focuses on risk management and hazards. Wilson (1990, 65) suggests that the aim of risk education would therefore include:

> An involvement in hazard and risk identification and mitigation; understanding of the social and environmental impacts of hazards; an ability to deal personally with hazards; positive attitudes, appropriate skills and behaviours in community disaster, preparedness, prevention, response and recovery; awareness of their rights and responsibilities as citizens with respect hazard management and, awareness of the structures in society which deal with hazards.

Across these different fields and ideas of risk education, there are broad themes that risk education includes fundamental or disciplinary knowledge, technical knowledge and contextual or community knowledge. These different types of knowledge are drawn from varied fields and disciplines including risk analysis, mathematics, science and geography and are also realised in other school subjects such as PSHE. Broadly speaking, the educational research considered above which explore ideas of risk are subject-specific and predominantly address what could or should be taught rather than what is taught. The current research looks at what aspects of risk are taught as part of the National Curriculum, along with what teachers, teacher educators and other experts in education consider to be the challenges, barriers and opportunities to teaching about risk. Through this study we aim to further develop a conceptualisation of risk education as understood in the context of secondary schools.

3. Methods

This exploratory mixed-methods study explores current practice and future potential of risk education in secondary schools in England. The first phase of research included documentary analysis of National Curriculum and Examination Specification documents. The second phase included the collection and analysis of insights and expertise gathered through interviews with teacher educators and secondary school teachers. The researchers sought to position interview participants as 'knowing and approving experts' (Edwards and Holland 2013) and this approach extended throughout two phases of data collection: (1) interviews with teacher educators and other experts in education, and (2) interviews with expert secondary school teachers.

The two phases of research are interrelated and aim to triangulate information to address the four research questions as shown in Figure 1. We adopted two types of triangulation: triangulation of methods (document analysis and interviews) and triangulation of data (interviewing people with expertise and understanding of education systems and curricula, and people who are experts in education and teaching in secondary schools). Further triangulation occurred because both sets of interviews involved diverse participants.

The analysis of the National Curriculum documents provides a context of official statements about what is supposed to be taught in schools which then is tested with the interviews which outline the reality as expressed by teachers and teacher educators. Ethical approval for the study was obtained from the relevant institutional ethics committee and voluntary informed written consent obtained from participants.

3.1. Content analysis of national curriculum and examination specification documents

All National Curriculum documents which covered secondary phases of schooling (Key Stage 3, 4 and 5) in England and were publicly available on government websites were included in the review (a total of 10 documents). In addition, as England has three exam boards (AQA, OCR and Pearson Edexcel), publicly available Examination Specifications which cover Key Stage 4 (General Certificate of Secondary Education, completed by students aged 15–16 years) and Key Stage 5 (Advanced-levels, completed by students aged 17–18 years) from each of these exam boards and examples of examination scripts were included in the analysis (a total of 36 documents).

A conventional content analysis (Hsieh and Shannon 2005) was employed to examine the National Curriculum and Examination Specification documents in-depth. Drawing on conceptualisations of risk education identified in through the SRA report (Aven et al. 2018), key concepts and terms were identified. Specifically, there was a focus on identifying instances where risk or risk-related concepts were mentioned. While 'risk' was a clear key term to identify, other terms and phrases, such as those related to decision-making, in various contexts were identified and included as a category (for example risk perception).

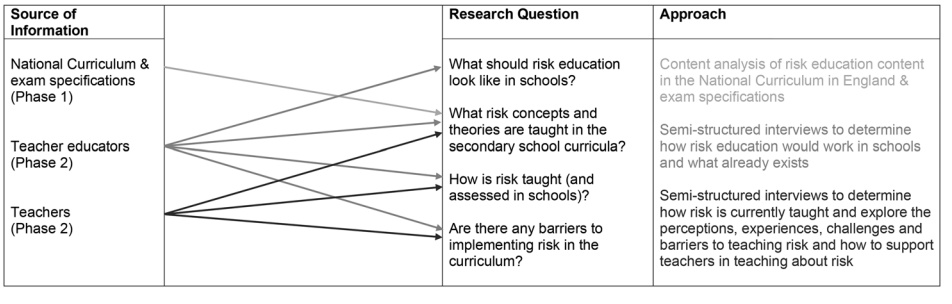

Figure 1. Schematic summary of overall research approach.

All National Curriculum and Examination Specification documents were analysed, with risk-relevant items highlighted, and a preliminary assignment to a cluster of interest made. This method allowed us to systematically explore the textual content, and identify official statements about risk education within the curriculum. A combination of inductive coding (letting the data speak rather than imposing predetermined categories) and deductive coding (drawing on emerging conceptualisations of risk education identified through the literature review, and the views of risk experts (Duckett, Löfstedt, and Rushton 2024)), was used to identify key phrases, themes and recurring concepts associated with risk. For example, we used the concepts identified in the SRA report (e.g. risk assessment, risk communication) and ideas present in education literature (hazards, probability, uncertainty, decision-making) as a starting point for document analysis, questioning the extent to which these codes and ideas were present. We also considered silences and absences in the documents and questioned how visible concepts were presented and framed in the document. These codes were developed into themes and were used to formulate the question guide for the semi-structured discussions with interview participants.

3.2. Education expert interviews

Semi-structured interviews (each lasting 25–30 min) were completed by author one, with 14 education experts and 11 teachers during December 2022–June 2023. Participants were recruited through the researchers' networks and through 'snowballing', where participants were asked to recommend other people who might usefully contribute to the study (see Table 2, names changed to protect anonymity). Consistent with interview-based studies which are widely used in educational research, interviews took the form of conversations with a purpose, rather than rigid schedules of questions (see for a recent example, Rushton and Bird (2024)). This approach of hierarchical focusing (Tomlinson 1989) involves commencing conversations with a prompt or general question from the highest level of the hierarchy (e.g. what do people understand risk education to mean?) opens up dialogue and avoids leading questions. The purpose is to build rapport, elicit general discussion, after which the interview can progressively focus in on more specific topics, using prompts from lower in the hierarchy: mid-level (for example, what practices are people implementing (or not) in relation to risk education?) and low-level (for example, questions which focus in on aspects of specific practices including assessment and content selection and organisation).

Video interviews were held online to provide flexibility for participants. Interviews included questions about participants' current role, expertise and relevant previous professional experiences. Participants were invited to describe and/or define risk education; to share whether and how risk education is and might be taught and assessed in secondary schools; and to discuss the challenges and affordances of risk education in secondary schools. Participants were invited to share examples of curriculum documents and/or other resources which include risk education to supplement the document review.

All authors were involved in the analysis of data from the interview transcripts. Qualitative content analysis (Hsieh and Shannon 2005) was used because it is appropriate for research teams working with large qualitative datasets. Through multiple rounds of analysis which took place individually and through regular group discussion, researchers identified themes (patterns of meaning across the dataset) through a process of abduction and retroduction (Edwards, O'Mahoney, and Vincent 2014). This involved the following steps. Firstly, the creation of interview transcripts provided an opportunity for close reading of the data both as individual contributions and across the data set as a whole. Secondly, a written summary of each interview was created, including the identification of significant quotes, and these were compiled in a spreadsheet to further enable analysis across the dataset. Thirdly, open coding was undertaken of the data compiled in the spreadsheet to generate themes and finally, these themes were interrogated in the context of the literature which informs this research, including prior research undertaken

Table 2. Participant profiles of teacher educators and teachers.

Pseudonym	Participant profile
Allan	Former Her Majesty's Inspector
Natalie	Senior Researcher in Assessment
Mary	Teacher Educator in Business Studies
James	Teacher Educator in Citizenship & PSHE
Daniel	Teacher Educator in Geography
Emma	Teacher Educator in Geography
Alice	International Teacher Educator & Advisor in Religious Education
Tarun	Teacher Educator in Mathematics
Alessia	Teacher Educator in Mathematics
Lee	Teacher Educator in Science
Benjamin	Teacher Educator in Science
Henry	Teacher Educator (subject not disclosed)
Olivia	Teacher Educator (subject not disclosed)
Simon	Teacher Educator (subject not disclosed)
Rory	Geography Teacher
Robert	Geography Teacher
Elle	Geography Teacher
Isabella	Geography Teacher
Layla	Geography Teacher
Peter	Geography Teacher
Carly	History Teacher
Heather	Science Teacher
Xun	Science/Chemistry Teacher
Delilah	Science/Physics Teacher
Elisa	Sociology & History Teacher

with risk experts (Duckett, Löfstedt, and Rushton 2024). Again, a combination of inductive and deductive approaches to content analysis were used in developing the coding frame. An initial set of codes was derived from the research questions (a deductive approach), but new codes were added in the light of the answers to the interview questions (an inductive approach). Our analysis followed a hybrid approach that combined both inductive and deductive coding (Fereday and Muir-Cochrane 2006). The deductive aspect was guided by insights from existing literature on teaching risk (e.g. Aven and van Kessenich 2020) and a content analysis of the National Curriculum. Simultaneously, we adopted an inductive approach, examining individual responses across both questions to identify emerging patterns.

As researchers, we saw our role as organising and interpreting data to identify patterns and themes. Additionally, our professional experiences—as university-level risk educators, teacher educators, and education researchers—influenced our analytical lens. The third stage of analysis occurred during the writing process, with all authors reviewing and discussing data to refine classification consistency and theme focus. This stage also allowed for further triangulation of the identified themes through deeper engagement with existing risk education literature. This grounded, constructivist approach allows for the development of themes which are then brought into conversation with ideas from the wider literature (Charmaz 2000).

Data are reported according to whether it was derived from a teacher or teacher educator contribution and data from both groups are included to support each key point. This open approach to identifying themes had the advantage of not imposing theoretical perspectives or the perspectives of other groups such as risk experts on the data. Authors ensured the conclusions were an accurate reflection of the interviews through discussion amongst researchers and by reviewing interview transcripts throughout the period of analysis.

4. Findings

Three themes were identified about: (1) what aspects of risk are taught and where in the curriculum, (2) the challenges and barriers to teaching risk; and (3) opportunities to enhance the

teaching of risk. The first two of these themes address the research questions identified prior to the interviews. The third theme arose from the responses of the interviewees.

4.1. Theme 1: The place of risk in the secondary school curriculum in England

In England, the Department for Education sets the National Curriculum which is organised into three 'key stages' across secondary schooling (Department for Education 2014a). The National Curriculum includes the subject content which schools are expected to teach in Key Stage three (Year 7–9, students aged 11–14 years) and Key Stage four (Years 10–11, students aged 15–16 years) (The Office of Qualifications and Examinations Regulation (Ofqual) 2019). Exam boards develop 'exam specifications', exams based on the National Curriculum requirements and assess and award General Certificate in Secondary Education (GCSE) to successful candidates (AQA 2014; The Office of Qualifications and Examinations Regulation (Ofqual) 2019).

The Society for Risk Analysis (2021) outlines the fundamental principles of risk analysis as covering two main types of knowledge generation:

> (A) Risk knowledge related to specific activities (interpreted in a broad sense covering also natural phenomena) in the real world, for example the use of a medical drug, the design of a process plant, or the climate.
>
> (B) Generic knowledge on concepts, theories, frameworks, approaches, principles, methods and models to understand, assess, characterise, communicate and (in a broad sense) manage risk.

Risk analysis is present in four main areas in the National Curriculum for Key Stages three and four: (1) probability in mathematics which is type B knowledge generation; (2) risk evaluation and (3) risk perception in science which is also type B knowledge generation, and (4) specific hazards which are taught as part of geography (e.g. climate change) and Personal, Social, Health and Economic education (PSHE) (e.g. risk areas such as drugs and alcohol) and which are type A knowledge generation. These four main areas are now considered in more detail.

4.1.1. Probability in secondary mathematics

Probability is central to risk. For example, Aven and Renn (2009) have argued that, when reviewing risk definitions, many authors have defined risk 'by means of probabilities and expected values'. Aven and Renn (2009, 2) reviewed many of the contemporary definitions of risk and determined that the definitions could be divided into two categories:

A. Risk is expressed by means of probabilities and expected values
B. Risk is expressed through events/consequences and uncertainties

Probability is commonly used in definitions of risk, much of the technical literature uses the standard definition of probability times consequence (or outcome) (Aven and Renn 2009). Probability is taught in Key Stage three and Key Stage four mathematics (Department for Education 2014b).

Key Stage three incorporates the fundamentals of probability, while Key Stage four involves application of the foundational concepts including more complex concepts such as conditional probabilities (Table 3). Assessment of probability concepts include requiring students to either draw a frequency tree or fill in the blank sections of frequency trees in mathematics exams (AQA 2015; Oxford Cambridge and RSA 2015; Pearson EdExcel 2015). This is consistent with advice from Spiegelhalter and Gage (2015) who highlight the importance of teaching frequency

Table 3. Risk education in Key Stage 3 and 4 mathematics curricula.

Key stage	Probability concepts in the mathematics curriculum
Three	• record, describe and analyse the frequency of outcomes of simple probability experiments involving randomness, fairness, equally and unequally likely outcomes, using appropriate language and the 0–1 probability scale
	• understand that the probabilities of all possible outcomes sum to 1
	• enumerate sets and unions/intersections of sets systematically, using tables, grids and Venn diagrams
	• generate theoretical sample spaces for single and combined events with equally likely, mutually exclusive outcomes and use these to calculate theoretical probabilities
Four	• apply the property that the probabilities of an exhaustive set of mutually exclusive events sum to 1
	• use a probability model to predict the outcomes of future experiments; understand that empirical unbiased samples tend towards theoretical probability distributions, with increasing sample size
	• calculate the probability of independent and dependent combined events, including using tree diagrams and other representations, and know the underlying assumptions
	• calculate and interpret conditional probabilities through representation using expected frequencies with two-way tables, tree diagrams and Venn diagrams

trees. Understanding probability, what Gal (2012) calls 'probability literacy' is core to understanding risk. Gal (2012) defines probability literacy as

> the ability to access, use, interpret, and communicate probability-related information and ideas, in order to engage and effectively manage the demands of real-world roles and tasks involving uncertainty and risk.

Most teachers, teacher educators and other experts in education in this sample identified only two areas of risk known to be taught in the curriculum: risk assessment and decision-making, with the latter mentioned most frequently. Decision trees and decision-making skills were mentioned by participants as being taught in Mathematics, Geography, and Business Studies.

> So what's risk education? I guess it's, it would be all of the activities, wouldn't it that help to sensitize students perhaps to the concept of risk and how risk is present in decision making? […] We have decision trees in business, which I guess would be connected to that. But we don't normally teach that until sixth form. (Mary, Teacher Educator in Business Studies)

While some participants mentioned probability being taught in schools, none mentioned resources that had been identified in our review of the literature, such as the textbook on *Teaching Probability* by Gage and Spiegelhalter (2016), even after being asked about teaching resources.

Probability is commonly used in definitions of risk, much of the technical literature uses the standard definition of probability times consequence (or outcome) (Aven and Renn 2009). So, teaching one half of that, probability, is a good starting point but the opportunity to connect probability to decision making, using a risk frame, seems to be de-emphasised, representing a missed opportunity.

4.1.2. Risk evaluation and risk perception in secondary science

Risk is specifically mentioned as part of both Key Stage three and four science (Department for Education 2014c). Key Stage three specifies that students should be taught to 'evaluate risks', while in Key Stage four, students should have an understanding and first-hand experience of 'evaluating risks both in practical science and the wider societal context, including perception of risk'.

The science curriculum is more explicit regarding the practical application of risk to decision problems than the mathematics curriculum. In both the Key Stage three and four science curricula, risk is referred to alongside the teaching of how scientific methods and theories develop, the importance of peer review, and the communication of results (Department for Education 2014c). Assessment of risk includes requiring students to be able to explain the 'risks and benefits' of the use of stem cells in medicine, and of genetic engineering and gene technology in

agriculture and medicine (AQA 2016a; Oxford Cambridge and RSA 2016c; Pearson EdExcel 2016a). Students are also expected to be able to identify risk factors associated with certain diseases including cardiovascular disease, some cancers, and type 2 diabetes, along with being able to discuss the risks of radiation exposure and risk implications of climate change (AQA 2016a; Oxford Cambridge and RSA 2016c; Pearson EdExcel 2016a).

Many participants emphasized the importance of teaching students about risk assessment in subjects such as Science and Geography. This extended to contexts where students learn to weigh up risks and make decisions.

> We teach students to look at risks involved in practical, what's the risks [sic] involved in doing experiments where there may be electricity or dangers of things falling on their feet … And so they all do risk assessments. I think in biology they teach about risk in the sense of vaccine rollout and weighing up the risks of the implications of not having something like MMR. […] So I think that is taught in schools and it's questioned in exams (Delilah, Teacher in Science/Physics)

Risk perception is also included in the science GCSE specifications published by AQA and OCR. For example, AQA (2016a) states that students could be asked to 'suggest reasons why the perception of risk is often very different from the measured risk (e.g. voluntary vs imposed risks, familiar vs unfamiliar risks, visible vs invisible hazards)', while OCR (2016a) includes learning outcomes which expect students to look at situations where there has been a scientific or technological advance and be able to:

- identify risks and benefits to the different individuals and groups involved
- discuss a course of action, taking account of who benefits and who takes the risks
- suggest reasons for people's willingness to accept the risk
- **distinguish between perceived and calculated risk** (emphasis in original).

This is explained further by Oxford Cambridge and RSA (2016a) in teaching notes that state:

> Everything we do carries a certain risk of accident or harm. New technologies and processes can introduce new risks. The size of a risk can be assessed by estimating its chance of occurring in a large sample, over a given period of time. To make a decision about a course of action, we need to take account of both the risks and benefits to the different individuals or groups involved. People are generally more willing to accept the risk associated with something they choose to do than something that is imposed, and to accept risks that have short-lived effects rather than long-lasting ones. **People's perception of the size of a particular risk may be different from the statistically estimated risk.** People tend to over-estimate the risk of unfamiliar things (like flying as compared with cycling), and of things whose effect is invisible or long-term (like ionising radiation)

Despite a curriculum highlighting the need for students to understand perception of risk, no exams from any of the exam boards between 2018 and 2022 asked questions related to perception of risk. Over those four years, some exam papers include one question asking students to suggest risks and benefits of genetic modification in agriculture or medicine. It seems that students being able to 'suggest risks and benefits' of a specific example given in an exam is considered enough to cover the 'evaluating risks both in practical science and the wider societal context' (Department for Education 2014c) portion of the National Curriculum.

4.1.3. Teaching about specific hazards in geography and PSHE

In both the Core Subjects of Risk Analysis document, and in work by Duckett, Löfstedt, and Rushton (2024), real-world risk and risk decisions in every-day life were seen as a priority for risk education. The geography curriculum is an example of teaching to specific hazards that students may face or have to understand in every-day life. However, there is no explicit mention of risk concepts in Key Stage three geography (Department for Education 2013). However

Key Stage four exam specifications incorporate references to climate change and the consequences of various natural hazards, for example referring to flood risks and the consequences and mitigation strategies of climate change (AQA 2016b; Oxford Cambridge and RSA 2016b; Pearson EdExcel 2016b). Climate change is clearly an important risk for students to consider, but the focus on the consequences of specific hazards and potential risk mitigation rather than public policy and/or risk decision-making, reduces the generalisation of risk education to other contexts.

A Geography teacher educator underscored the explicit teaching of risk assessment and decision-making processes in schools.

> So we explicitly teach risk assessment. We explicitly teach decision making. How do you go through the steps? How do you go through considering what are the appropriate mitigations and what are the appropriate things to put in place? (Daniel, Teacher Educator in Geography)

The PSHE curriculum is divided into three areas: relationship education for primary school, relationship and sex education for secondary school, and health education for both primary and secondary school students (Department for Education 2019). The Department for Education (2019) highlights that through PSHE, 'Pupils can also put this knowledge into practice as they develop the capacity to make sound decisions when facing risks, challenges and complex contexts'. The PSHE Association (2020) guidance document discusses key areas for schools to focus on. These involve many risks that students potentially face in everyday life including: (1) health-related decisions; (2) risks associated with consumption of alcohol, illicit substances and nicotine; (3) risks associated with unprotected sex; (4) online safety; (5) financial risks, and (6) media literacy and the accuracy of media sources. In common with the specific example of climate change, evaluation of the specific personal risks may not generalise to risk evaluation more broadly.

4.2. Theme 2: Challenges and barriers to teaching risk in schools: assessment, legitimacy and resources

Participants were invited to reflect on challenges and barriers to the teaching of risk concepts in the classroom. They nominated three broad classes of challenges to expanding or even maintaining risk education in secondary schools: assessment, legitimacy (inclusion in the National Curriculum) and resources.

4.2.1. Assessment

Participants emphasised the links between student assessment and the ability of classroom teachers to incorporate risk and risk concepts into the 'knowledge led' curriculum. As a Teacher Educator points out, this 'knowledge-led' curriculum is a significant barrier to incorporating risk education in schools. The focus on knowledge-based syllabuses and teaching to the test leaves little room for risk education.

> I think there were things that work against [teaching risk] in schools. One of those would be sort of specification, sort of GCSE and A level specification, in the UK context are very knowledge led. And that kind of came into fruition with, particularly with the last change in curriculum in our GCSE, which would've been around 2009. We had what we call a knowledge turn […] There's definitely far less room because the syllabuses aren't designed in that way. They're designed on a more knowledge basis. […] Because I do think it encourages teachers to teach to the test for the content, right and wrong, move on. And there is less room, if you like, in a classroom to do those soft, you could call them softer skills. But I think that's probably downplaying risk, because I think it shouldn't be referred to as a softer skill. It should be an essential skill but that's often how it's referred to. So, I think there's less room because of strict syllabuses that have been kind of dictated to schools. (Olivia, Teacher Educator)

Several participants noted the overlap between formal assessment and the legitimacy of teaching about risk.

> To be honest with you, the only way of really getting it taken seriously on the school curriculum is to have it featuring in the exams. (Allan, Former Her Majesty's Inspector)

This highlights a potential issue with the current assessment system, as it may not adequately provide an incentive to devoting classroom time to the teaching of risk, which is seldom featured in exam questions. As outlined earlier, there have been very few exam questions related to risk between 2018 and 2022.

The 'knowledge turn', referred to by Olivia, (quoted above) is an important context for teaching risk in secondary schools. Education related to hazards students may face in everyday life, as outlined in the PSHE Association (2020) guidance necessarily involves students reflecting personally, which may not sit easily with the more objective approach to exam-based assessment.

4.2.2. Time, training and resources

The lack of teaching time, teacher training, and specific risk education resources is another challenge identified by participants. A Geography Teacher, notes the difficulty of fitting risk education into the school year and the lack of age-appropriate resources or frameworks for thinking about risk.

> We have so little time in the school year to cover topics that we'd have to consider how we fit that in and where it would fit and what we could maybe move or get rid of to fit it into our time. I suppose also it's maybe having age-appropriate resources or frameworks to think about risk, because naturally students who are lower down the school might think about things in maybe a more direct way, a less nuanced way […]so getting them to do that thinking independently I've not come across many resources that do that. (Elle, Geography Teacher)

A number of participants also highlighted that the current National Curriculum focuses on knowledge over the application of knowledge and skills.

> [W]ith the way the National Curriculum is now taught […] there's much more of an expectation of knowledge rather than application of knowledge and skills at GCSE and A Levels than there used to be. Therefore, teachers are kind of restricted by a time of what they've got to teach and so on. (Alice, International Teacher Educator & Advisor in Religious Education)

Multiple participants suggested that risk education should be introduced in professional learning for teachers indicating a need for more support and resources in this area.

> It should be introduced very early on not just for science teachers, but for all teachers to say children are going to be exposed to risk in their lives, and we need them to take risks, but they need to be able to understand how big or serious those risks are. So I'd suggest we need to put it into very much early training for teachers and then reinforce it onwards and upwards. I've never had a CPD session on risk assessments or risk. (Heather, Science Teacher)

> I guess maybe training around how to prevent bias from creeping in. So I don't know whether, even if you think about risk assessments, whether there are models out there that exists for field trips that are designed to try and eliminate the subjectivity. (Isabella, Geography Teacher)

Isabella, quoted above, highlights here the opportunities for teacher professional learning and development. Subject associations and exam boards are both places where risk education and teacher education take place, while universities have opportunities to support consolidation of risk education, across teacher education and risk research. Universities, exam boards and subject associations all could be spaces to provide context to take forward professional learning in risk education. However, collaboration between experts in risk, teacher educators and teachers is needed to design a unified cross-disciplinary curriculum and develop appropriate pedagogical approaches to teaching and assessment.

4.3. Theme 3: Opportunities to enhance risk education in secondary schools

Teachers and teacher educators in this sample were favourably disposed toward risk education and engaged positively with questions about how this could best be achieved given current educational policies.

A few participants were familiar with academic literature used in risk science. A Maths teacher educator referred to Kahneman's (2012b) work on *Thinking Fast and Slow* and used real-world examples to illustrate statistical risks, such as the perceived versus actual risk of flying on a plane.

> I might look at things like, do you know Kahneman's work on *Thinking Fast and Slow*? So I might bring some of those examples about, can't remember if this is from him, but if you ask a lot of people about the risk of flying on a plane or traveling in a car a lot of people say it is really risky to travel on a plane, but we know statistically why that's not true and things like that. So that's the sort of thing I bring in because it's not explicit in the curriculum. (Tarun, Teacher Educator in Maths)

While this is promising, no education experts made any mention of the decision-making curriculum developed by Kahneman and Fox (Kahneman 2012b) and Beyth-Marom and Dekel (1985).

A Sociology & History teacher brought up the sociology of risk and Ulrich Beck's *Risk Society* (Beck 1992). This shows more reading of risk related literature although this really is not specifically risk assessment or decision making. It does show awareness of risk literature.

> [I think] immediately about sort of the sociology of risk and Ulrich Beck and *Risk Society*. And how I would talk about that in the classroom is very much determined by the syllabus that I'm following. So, when we cover that stuff, it's usually looking at trends and changes in society and what's created risk in society. (Elisa, Sociology & History Teacher)

When presented with a number of concepts recommended by risk experts (Duckett, Löfstedt, and Rushton 2024), teachers were interested in how they could integrate certain concepts into their current teaching.

> I like that optimism bias as you called it. That's very interesting. I feel like that's the hardest thing especially when we're teaching risk assessment, almost that optimism bias might blend into it. […] [That]'s something that could fall into my teaching. (Robert, Geography Teacher)

This shows an interest in building on current practices and developing what already exists in the National Curriculum.

Risk is intrinsically interdisciplinary and risk education creates opportunities for subjects in secondary schools to work together to enhance student understanding of risk. The National Curriculum does not seem to be set up for interdisciplinary collaboration, as a Geography teacher mentioned when asked about communication between subjects.

> [Collaboration between subjects is] definitely something that is becoming more common. […] If you get on well with other teachers in other subjects and you kind of have those open conversations about what they're working on and what you are working on, then it happens. But again, it's much more informal I would say. (Rory, Geography Teacher).

Relying on such informal collaborations across teaching areas will result in a patchwork of understanding of risk from one secondary school to the next. Interdisciplinarity is difficult to create and sustain given the way the National Curriculum is currently structured. The National Curriculum considerably limits the degree of autonomy currently given to teachers. They are obliged to stay within the confines of their discipline area.

5. Discussion and implications

Here we discuss the potential implications for research, policy and practice across themes of teaching and assessment of risk education in secondary schools and teacher professional learning. Drawing on insights from this research we outline a conceptualisation of risk education and consider future directions for risk education research and practice.

5.1. Teaching and assessing risk education in schools

Despite common perceptions of people external to the education world that risk is not taught in schools, this research demonstrates that risk education is in fact a visible part of secondary school education in England. For example, the content analysis shows that there are risk concepts already integrated into some subjects such as Mathematics and Science, along with specific hazards for some subjects to focus on in subjects such as PSHE and Geography.

Similar to the findings of Bardsley (2017), the interviews showed that teachers are enthusiastic about risk education. Working with the enthusiasm for teaching risk from teachers, one way forward for risk education could be to build on what already exists in the National Curriculum, to incorporate more risk-specific questions in exam specification and develop support for teachers to ensure that risk education is part of the enacted curriculum. For example, previous research has underlined that teachers lacked confidence in teaching some aspects of PSHE which they felt was outside their subject area expertise and training (Davies and Matley 2020; Evans and Evans 2007). Therefore, it is highly possible that teachers may also experience uncertainty about teaching risk in other subjects. A possible way to address this lack of confidence might be to integrate further support from risk experts, through contributing to teacher professional learning programmes and the development of bespoke teaching resources in collaboration with teachers. Learned Societies, including the Royal Geographical Society, could play an important role in bringing together expertise from both the discipline of geography and school-based geography to bridge this important divide.

Participant interviews underscored the importance of assessment in shaping what is taught. The school curriculum in England is frequently understood and experienced as being driven by assessment. At the same time, our content analysis showed that risk concepts are infrequently included in examinations. For example, the concept 'perception of risk' is included as a point bolded in the documents of exam board OCR (Oxford Cambridge and RSA 2016a), yet has not been included in any exam questions. Given the influence on assessment in school education in England, without exam questions on risk, this crucial topic may well be side-lined in the classroom as teachers make decisions on how to teach a content-heavy curriculum. In addition, there are tensions between science-based risk assessment and the development of more personal life skills of students as anticipated in the PSHE curriculum which require different approaches to pedagogy and assessment.

5.2. Teacher professional learning and risk education

Study participants expressed interest in and recognised the importance of risk education, but felt that they had few teaching resources, and more importantly, little time in the crowded curriculum to teach subjects not valorised in exams. While most participants could identify teaching content consistent with risk education, this perceived lack of support for more risk education was seen as the primary barrier for teachers.

The interviews show that teachers and teacher educators have a positive disposition towards risk education, recognizing its value in fostering a risk-intelligent society. However, the gap between the National Curriculum and classroom implementation highlights the challenges faced in translating policy into practice. Future research to help overcome these challenges might include classroom observations, work with children and young people to explore their experience of a variety of risk education approaches, and evaluating their impact on student understanding.

The field of risk, including the Society for Risk Analysis and risk practitioners, has a crucial role to play in bridging this gap. By building a network with teachers and providing them with the necessary support and resources, they can help ensure that risk education is not just a theoretical concept in the curriculum, but a practical reality in the classroom. This could involve facilitating training workshops, developing teaching resources, or even collaborating with exam boards to ensure that risk-related topics are adequately represented in assessments. The risk community can continue to advocate for the importance of risk education at a policy level, influencing curriculum development and assessment strategies.

5.3. Returning to a conceptualisation of risk education

Looking across our findings from both the documentary analysis and interviews with experts, it is possible to articulate the following ideas and thinking about risk education, particularly in the context of schools in England. Firstly, risk education involves teaching and learning about the concept of risk, the assessment of risk, risk perception, risk community and management, with a strong emphasis on decision-making in real-life situations. Secondly, risk education includes understanding the probability and impact of unwanted events, and how to analyse, evaluate, and mitigate these risks to make informed decisions. Thirdly, an aim of risk education is to equip individuals with the knowledge and skills to navigate uncertainties effectively, whether in areas such as public health or environmental issues. To achieve this aim, risk education integrates concepts from various disciplines including mathematics, psychology and the social sciences to enable a comprehensive understanding of risk itself and risk in real-life contexts. Therefore, risk education is necessarily interdisciplinary, it involves disciplinary, technical and applied knowledge, it is complex, and is itself an emergent area of education. We argue that this conceptualisation of risk education is an important and significant contribution to our understanding of the nature and purpose of risk education.

5.4. Future directions for risk education research and practice

Across this discussion of the findings and the implications of this research for the future of secondary-school based risk education, we have drawn on data derived from interviews to identify some of the key barriers and explore potential ways forward. However, it is important to note that even given the long-standing calls for risk education, very few have resulted in system-wide adoption. We suggest two key reasons for this.

Firstly, risk education itself is an emergent area, where ideas of what is and is not part of risk education continue to be explored and contested. Whilst this makes for a dynamic area of study, it presents an inherent challenge for those seeking to teach it, in whatever phase of education. Future research on typologies of risk education, drawing from different phases of education in a range of international contexts would be an important next step.

Secondly, our findings underline that risk education, consistent with other emerging areas of education such as climate change education are inherently interdisciplinary and bring together a range of disciplinary, technical and applied knowledge. Much of the recent climate change education literature offers insights as to what might constitute effective or quality education for such complex and multifaceted areas (Monroe et al. 2019; Rousell and Cutter-Mackenzie-Knowles 2020) and these could provide a helpful starting point for researchers and educators. However, the interdisciplinary nature of risk education is at odds with the siloed approach to school subjects which is an inherent part of much of secondary school education in England. We argue that for risk education to be available for all young people, there are significant structural barriers to address in education systems which are beyond the remit of committed teachers and school leaders.

Thirdly, a possible limitation of the interview sample points to a need for further research. The group of teachers, teacher educators and other experts are mainly drawn from networks of author two resulting in a larger group of participants specialising in Geography. While Geography is one of the subjects identified as having risk taught, multiple other subjects also include risk. Mathematics, for example, has a large amount of risk in the curriculum. While mathematics teacher educators were interviewed in this study, mathematics teachers may have expressed different views or nominated different resources and risk concepts when discussing risk education.

6. Conclusion

Our research has found that despite the commonly held view that risk education does not exist in secondary school curricula, it is, in fact, taught across a range of subject areas. What is missing from this picture, however, is system-wide integration of risk concepts into those subjects. Such a systematic approach would include better preparation of teachers in the relevant subject areas, incorporation of risk concepts in assessment of those areas, and creation of teaching resources to build the confidence of teachers. Teachers and teacher educators favoured risk education as part of the curriculum, noting both the importance for students of understanding the underlying concepts, but also the importance of these concepts in their current and post-school lives. Some educators had read risk literature, but given the crowded curriculum in the disciplines highlighted, better in-service professional learning and research-informed teaching resources would strengthen the confidence of all educators in these subject areas to confidently teach about risk. Further research and discussion are needed to continue to develop a shared understanding of the nature and purpose of risk education, including typologies of risk education, as an essential next step towards enabling systematic approach.

While there are challenges to be overcome, risk education has a significant part to play in enabling people to live happy and healthy lives. Therefore, it is incumbent upon a range of groups - teachers, educators, the risk community, and policy makers - to work together to realize this potential and equip future generations with the knowledge and skills they need to navigate an increasingly complex and uncertain world.

Ethical approval

Institutional ethical approvals from King's College London Research Ethics Office were obtained prior to the commencement of this study (MRSP-21/22-28869).

Informed consent

All research participants consented to take part.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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