“I COULD LOSE SOMETHING”: EMOTIONAL INFLUENCES ON MEASURING VOCATIONAL STUDENTS’ RISK LITERACY

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Probability literacy is a vital skill for vocational students, yet it remains a neglected area in research, despite its relevance to real-world decision-making. While probability education is standard in pre-university tracks, vocational students, who make up 50% of Dutch secondary education, receive little formal instruction, leaving them vulnerable to risky behaviours like gambling. This study aims to explore how vocational students reason about probability and risk, and how emotions and heuristics influence their decisions. Using a questionnaire with six risk-literacy items, we surveyed 355 students (ages 13–15) and found that many declined games with positive expected values, often due to fear of losing or aversion to gambling. The qualitative explanations revealed that emotional and intuitive reasoning frequently overrode analytical thinking, even in low-stakes scenarios. These findings highlight the need to address cognitive and affective biases in probability education for vocational students.

INTRODUCTION

In the Netherlands, 12-year-old students are tracked into either vocational or pre-university secondary education based on cognitive assessments. While probability literacy is critical for informed decision-making, vocational students, who comprise 50% of the Dutch secondary education, are often overlooked in research. This gap is concerning given their vulnerability to risky behaviours (e.g., gambling) and limited exposure to formal probability education. This study seeks to understand how emotional responses and heuristics shape vocational students’ reasoning about probability and risk, which is a question that has received limited attention in prior research. Pilot results of our study revealed that many vocational students declined games with positive expected values, suggesting that their reasoning about probability and risk may be influenced by factors beyond analytical skills. This study therefore addresses the following research question: “How do emotions and heuristics influence vocational students’ reasoning about probability and risk in low-stakes scenarios?”

THEORETICAL BACKGROUND

Risk permeates modern life, influencing decisions in health, finance, and civic participation. Its core lies in the intersection of probability and uncertainty (Radakovic, 2015). Central to this intersection is the understanding that risk is typically described by two key factors: the probability of harm and the severity of harm in the event of an occurrence (Hansen & Hammann, 2017). Probability literacy, or the ability to

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understand and reason with probabilities, provides the analytical foundation for assessing risks and making informed decisions in uncertain contexts (Borovcnik & Kapadia, 2018). A risk-literate individual not only comprehends probabilities but also recognises common cognitive biases, enabling better navigation of real-world uncertainties (Meder & Gigerenzer, 2014).

Risk literacy is also relevant in the context of online gaming and gambling, where probabilistic reasoning is essential for understanding risks. Adolescents, especially those in vocational education, are more vulnerable to develop gambling problems (Donati et al., 2018). Neurodevelopmental research shows that adolescents' decision-making is influenced by heightened sensitivity to rewards and emotions, often leading to intuitive, heuristic-based responses rather than analytical reasoning (Casey et al., 2008). Dual-process theory distinguishes between two modes of thinking: System 1, which is fast, automatic , and emotion-driven, and System 2, which is slow, effortful, and logical (Kahneman, 2011). This theory explains how intuitive (System 1) processes can override deliberate (System 2) reasoning when faced with uncertainty. For example, adolescents may avoid favourable bets simply to prevent losses, reflecting loss aversion, a heuristic bias that prioritises emotional comfort over rational outcomes (Kahneman & Tversky, 1979).

While existing research underscores the importance of probability literacy in mitigating risky behaviours, the specific ways in which vocational secondary school students reason about probability and risk remain unexplored. Adolescents in vocational education may rely on intuitive, emotion-driven responses when faced with uncertainty, especially when they lack formal probability training. This highlights the need for empirical investigation into how these biases influence their decision-making, especially in low-stakes scenarios. The following section outlines the methodology used to address this gap.

MATERIAL AND METHOD

Participants

The study involved two phases: A pilot phase with 75 grade-eight vocational students from four classes at the same school in April 2025 and a main study with 355 grade-eight vocational students from six schools in June and July 2025. In the Netherlands, probability is not part of the elementary school curriculum, so all participants had no formal knowledge of probability.

Questionnaire

The 35-item questionnaire on probability included six items targeting risk literacy (RL), which featured simple probabilistic contexts (e.g., dice throws, coin flips, spinning wheels), each accompanied by visual aids. Students provided Yes/No responses, followed by an open-ended explanation. In the pilot phase, the follow-up question asked, "I would play this game if I get ___ euros on a win," but this yielded

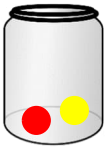
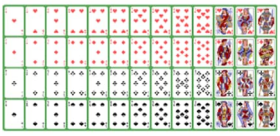
unrealistic responses with exaggerated monetary values. Consequently, the question was changed into “Explain your answer” for clarity in the main study.

Each of the six RL-items presented a probabilistic scenario where students decided whether to play a game with a chance of winning or losing. The items were designed to assess informal probabilistic reasoning and risk assessment. Below are the six RL-items:

- Item 1: Coin flip (Money): “Someone flips a coin. If it is heads, you win 4 euros. If it is tails, you lose 1 euro. Would you play this game? (Yes/No) Explain your answer.”
- Item 2: Marbles in a jar (Candy): “A jar contains 1 red and 1 yellow marble. If you pick the yellow marble you will get 4 pieces of candy. If you pick the red marble, you get nothing. You can also choose not to pick a marble, then you will get 1 piece of candy. What do you do choose? I (will/will not) pick a marble from the jar. Explain your answer.” (revised from Till, 2014)
- Item 3: Chips in a jar (Money): “A jar contains 10 chips. Two chips will gain a win of 4 euros. The other chips give a loss of 1 euro. You can pick as many chips as you like. You cannot put a chip back into the jar. Would you play this game? (Yes/No) Explain your answer.”
- Item 4: Card deck (Money): “Without looking you pick a card from a deck. If you card is clubs ♣, you win 4 euros. If your card is a different suit, you lose 1 euro. Would you play this game? (Yes/No) Explain your answer.”
- Item 5: Spinner (Money): “If this spinner ends on grey, you will win 3 euros. If it ends on the other colours, you lose 1 euro. Would you play this game? (Yes/No) Explain your answer.”
- Item 6: Die throw (Money): “You play a game with a die. If you throw 6, you win 4 euros. If you do not throw 6, you lose 1 euro. Would you play this game? (Yes/No) Explain your answer.”

Each item included a visual aid to clarify the situation (see Figure 1). Items 1 to 4 were designed with a positive expected value, ensuring that rational probabilistic reasoning would favour playing the game. Item 5 had an expected value of zero, while item 6 had a negative expected value.

Figure 1. Visual aids for the items.

Item 1	Item 2	Item 3	Item 4	Item 5	Item 6
					

Data Collection

Students' explanations for their Yes/No answers were collected via open-ended questions and later categorised for analysis. Data were collected in regular classroom settings, with students' own teacher present. The researcher emphasised that the questionnaire was not graded and encouraged students to answer honestly. To ensure anonymity, no names, ages or genders were recorded; however, questions regarding dyslexia and home language were included, given the linguistic demands of probability tasks. Prior to participation, students received information letters outlining the study's purpose.

Data Analysis

Internal consistency for the 6 RL-items was assessed using Cronbach's alpha. In the pilot study (n = 75), reliability was acceptable ($\alpha = 0.731$, mean = 0.538, SD = 0.295). In the main study (n = 355), alpha decreased to 0.578 (mean = 0.465, SD = 0.248), suggesting moderate consistency. This drop may reflect the influence of emotional or contextual factors on students' responses, as further explored in the qualitative analysis.

To investigate how emotional responses and heuristics shape vocational students' reasoning about probability and risk, open-ended responses were categorised into one group for 'yes' answers and four distinct groups for 'no' answers. Although the 'yes' answers revealed that students' decisions were not purely rational, the analysis centred on the reasons students provided for refusing to play, given that only one item had a negative expected value. The 'no' answers were categorised into four distinct themes:

- No gambling (heuristic-based reasoning).
- No (fear of losing, emotional).
- No (pessimism about winning, heuristic/emotional).
- No (other reasons).

RESULTS AND DISCUSSION

Across the six RL-items, a substantial proportion of students declined to play games with positive expected values, despite the probabilistic advantage. Table 1 summarises the distribution of responses, categorised by the four themes identified in the 'no' answers. Particularly Item 1 (Coin flip, which had the highest expected value), and Item 2 (Marbles in a jar, which had nothing to lose), still elicited 'no' responses from 29.3% and 37.4% of students, respectively. This avoidance was also pronounced in Item 3 (Chips in a jar), where 59.8 percent of students refused to play, possibly because the linguistic complexity of the question made it difficult for them to understand that they could not lose money. Item 6 (Die throw) showed the highest percentage of declination (65.1%), likely due to its negative expected value. The students' qualitative

explanations revealed that emotional and heuristic reasoning played a significant role in these decisions, even in low-stakes or advantageous scenarios.

Table 1: Percentage answers to the RL items.

Item	No gambling	No (fear of losing)	No (pessimism about winning)	No (other reasons)	Yes	N/A
1	7.3%	12.1%	1.1%	9.3%	69.7%	1.7%
2	0.0%	22.5%	2.5%	12.6%	59.6%	3.4%
3	3.4%	23.6%	9.6%	23.6%	36.0%	4.5%
4	5.6%	14.9%	17.7%	24.4%	35.1%	3.7%
5	7.0%	21.1%	15.2%	14.3%	42.4%	3.4%
6	6.7%	24.2%	18.8%	16.6%	30.3%	4.8%

Table 1 shows that the proportion of students who answered correctly (i.e., chose ‘yes’) for Items 1 to 5 was 69.7%, 59.6%, 36.0%, 35.1%, and 42.4%, respectively. For Item 6, which had a negative expected value, 64.9% of students answered correctly (i.e. chose ‘no’).

The No-gambling theme (3.4%–7.3% across items 1 and 3-6) reflected a principled aversion to gambling with statements like: “I have learned not to gamble” and “Gambling is dangerous.” This aligns with heuristic-based reasoning (Kahneman, 2011), where moral or social norms override probabilistic calculations. Remarkably, this theme was absent in Item 2 (Marbles in a jar), the only non-monetary item, suggesting that students associated gambling exclusively with money. The absence of moral or principled objections to this item highlights how context shapes adolescents’ definition of gambling. This distinction is particularly relevant for modern gaming environments, where non-monetary rewards (e.g., loot boxes) may not trigger the same aversion as traditional gambling, potentially normalising risk-taking behaviours in other contexts.

The fear-of-losing theme was the most prevalent, accounting for 11.5%–23.5% of ‘no’ responses. Students frequently cited fear of losing, even when the expected value was positive: “I could lose something” and “It’s a 50% chance, so also a big chance that you lose”. These responses exemplify loss aversion (Kahneman & Tversky, 1979). For

example, in Item 2 (Marbles in a jar), 22.3% of students preferred a guaranteed 1 candy over a 50% chance of receiving 4 candies.

The pessimism-about-winning theme (1.7%–18.7%) captured students' scepticism about their chances of winning, often framed as uncertainty. Responses such as "You don't know whether you will win" and "Small chance to win" suggest that students tended to underestimate the probability of success. This aligns with research on cognitive biases in probability judgement, where individuals often misjudge uncertain outcomes due to heuristics (Tversky & Kahneman, 1974).

The No-other-reasons theme (8.9%–24.0%) included pragmatic or idiosyncratic justifications, such as: "Why would I, 4 euros is of no use to me" and "It's pure luck, and I have more luck in love than in games." These responses highlight contextual or personal factors unrelated to probability.

In contrast, 'yes' responses (30.2%–69.0% across items) were the correct choice for five of the six items, as these had positive or neutral expected values. While these responses included probabilistic reasoning (e.g., "There is a 25% chance to win"), they also reflected personal or perceived strategic motivations (e.g., "It's funny" or "There are special ways to throw a die"). However, even in 'yes' responses, heuristic biases sometimes played a role, indicating that students' decisions were not always based on purely rational or mathematical reasoning (e.g., "6 comes up quick"). The primary focus of this study, however, is on understanding the reasons for refusal, which revealed consistent emotional and heuristic patterns across the 'no' responses.

The moderate internal consistency ($\alpha = 0.578$) in the main study suggests that students' responses were not purely probabilistic but influenced by emotional and contextual factors. This is supported by the qualitative themes, where heuristic and affective reasoning often overrides mathematical logic.

Overall, the results reveal that vocational students' reasoning about probability and risk is heavily influenced by emotions and heuristics, often overriding rational probabilistic calculations. The dominance of loss aversion, gambling aversion, and pessimism about winning (even in advantageous scenarios) highlights the gap between formal probability literacy and real-world decision-making. These findings underscore the need to address affective and cognitive biases in probability education, particularly for vulnerable populations like vocational students.

CONCLUSION AND FURTHER RESEARCH

This study reveals that vocational students' reasoning about probability and risk is shaped not only by analytical skills but also by emotional and heuristic influences. Qualitative explanations, such as "I don't gamble" or "I don't want to lose money," highlight how affective and intuitive processes often override mathematical logic, even in low-stakes scenarios. These findings align with dual-process theory (Kahneman, 2011) and loss aversion (Kahneman & Tversky, 1979), demonstrating that vocational students, like other adolescents, rely on intuitive shortcuts when faced with uncertainty.

However, our study uniquely extends this understanding by focusing on a population often overlooked in risk literacy research, emphasising the need to address both cognitive and emotional dimensions in probability education.

While the primary focus of this study was on reasons for refusal, 'yes' answers also showed a range of justifications, from probabilistic reasoning (e.g., "There is a 25% chance to win") to personal motivations (e.g., "It's funny"). This suggests that even when students accept probabilistically advantageous games, their reasoning is not always purely rational, indicating that heuristics may also play a role in 'yes' responses.

Future studies could investigate whether framing RL questions about "someone else" mitigates heuristics (e.g., asking students to advise a peer or to evaluate a hypothetical character's decision). Another possible avenue is to test interventions, such as gamified probability lessons or reflective exercises, to improve risk literacy and reduce the impact of emotional biases in decision-making. Additionally, comparing responses across different contexts (e.g., monetary vs. non-monetary rewards) or demographic subgroups (e.g., vocational vs. pre-university track, or socioeconomic background) could provide deeper insights into how risk perception develops in adolescents. Furthermore, longitudinal studies could track how emotional responses and heuristics develop over time in vocational students.

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