

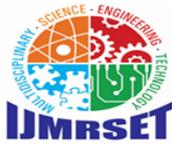
# International Journal of Multidisciplinary Research in Science, Engineering and Technology

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# The Cognitive Portfolio: Conceptualizing an Integrated Framework of Financial Literacy, Behavioral Biases, and Decision Making across the Lifespan

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**ABSTRACT:** This research paper offers an integrated framework that incorporates financial literacy, behavioral biases, and decision-making processes at different life stages to understand individual investment behavior. Despite the significant role that financial literacy plays in individual economic well-being, recent global assessments reported that shocking levels of financial literacy existed across diverse global populations; less than 30% of Americans got three basic financial questions right. This paper shows, through an extensive literature review and developed methodology that integrates both survey analysis and decision tree regression modeling, that individual investment behavior can be understood as hierarchical, where behavioral factors including investment attitudes, decision-making behavior, and financial education contribute to over 60% of decision-making influence for individual investment behavior. By not only positively impacting the quality of financial decisions for investments but also mitigating the effect of biases such as overconfidence and herd behavior, financial literacy is of immense value to the concerned individual. This paper aims to develop a new conceptual framework that outlines the key transition points of financial decision-making capability during developmental stages, while focusing on the loss of this capability due to cognitive aging. The benefits are thus outlined as to suggest the need for educational endeavors, while discrepancies are noted within demographics to promote recommendations for financial literacy. This combined approach unifies classical finance and behavioral finance, yielding valuable benefits to those involved in the field of finance.

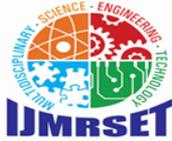
**KEYWORDS:** Financial Literacy, Investment Decision Making, Behavioral Finance, Cognitive Biases, Financial Education, Developmental Finance, Portfolio Theory, Financial Inclusion, Risk Perception, Economic Wellbeing.

## I. INTRODUCTION

Financial decision-making has significant personal and wider implications for economic security in an increasingly complex financial environment characterized by evolving investment products, digital transformation, and economic volatility [4]. The global financial crisis of 2008 showed in sharp detail the consequences of widespread financial illiteracy, as those who did not understand basic principles of finance made imprudent decisions, with devastating personal and systemic consequences. Since then, research has established that financial literacy—the understanding of basic concepts such as interest rates, inflation, and risk diversification—constitutes a critical determinant of investment behavior and long-term financial well-being [1].

However, financial literacy levels remain disconcertingly low despite its increased acknowledgment as an essential component around the globe [1][2]. Pioneering studies carried out by Stanford economist Annamaria Lusardi, employing "Big Three" financial literacy questions that have now been established globally as a standard benchmark, note that only 28.5% of Americans managed to correctly answer all three basic financial literacy questions by the year 2021, showing particularly worrying levels of financial ignorance pertaining to inflation (53.1%) and investment risk diversification (41.5%). Financial illiteracy appears to be an endemic problem, not only engaging American citizens but spreading across multiple nations from developed nations up to developing countries [2]. Of particular concern is that financial illiteracy appears to vary significantly across different demographic sections, amongst which particularly worrying levels amongst younger people, less educated people, women, and minorities [3].





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financial behaviors, such as planning for retirement, managing debts, and diversification of investments, which are considered core aspects of almost every financial investment [3].

This conceptualization has shifted the focus of financial literacy from mere knowledge acquisition to the application of the knowledge acquired [4]. According to the Organisation for Economic Co-operation and Development, financial literacy can be defined as "a combination of financial awareness, knowledge, skills, attitudes, and behaviors necessary for achieving personal financial wellbeing" [5]. This all-encompassing conceptualization of financial literacy acknowledges the fact that knowledge, on its own, is not sufficient but must be complimented with related confidence to effectively apply what has been learned in actual financial situations. According to Remund (2010), there is an emphasis on the importance of the application of the knowledge acquired, which impacts financial decision-making [7].

### 2.2 Investment Decisions and Behavioral Finance

The conventional approach to finance, based on the efficient market hypothesis, or rational expectations, has been heavily challenged by the discipline of behavioral finance that began to emerge over the last four decades [6]. Indeed, prospect theory, as formulated by Kahneman & Tversky, essentially revolutionized the study of decisions under conditions of risk as it challenged the conventional approach by verifying that people are essentially subject to loss aversion, or risk-seeking behavior for that matter [8].

#### Key behavioral biases identified in the literature include:

- **Heuristic Bias:** Rules of thumb or mental shortcuts used to make a difficult decision easier, which can often result in systematic errors, i.e., representativeness, availability, or anchoring biases.
- **Overconfidence:** The level of overconfidence, including overestimation of one's knowledge, skills, and forecasting accuracy, which was found to result in more trading but lower returns.
- **Herd Mentality:** The tendency to replicate various investment actions taken by the crowd and not carry out individual analysis, thus indirectly contributing to asset bubble formations.
- **Framing Effects:** The effect that presentation of equivalent information in different formats can lead to divergent decisions while keeping the underlying economic reality constant.

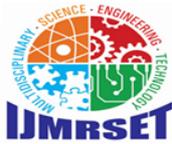
Research has proved that these behavioral factors have profound effects on investment decisions. Research among Palestinian investors found that their level of overconfidence actually enhanced the relationship between financial literacy and investment decision-making [9]. This proved that confidence, despite being unjustified, has a role in enhancing the application of knowledge. However, research among investors in India has shown that their level of heuristic bias, the framing effect, and herd mentality influence investment decisions negatively, while their level of financial literacy and cognitive behavior influence it positively [10].

### 2.3 Demographic and Developmental Perspectives

Financial literacy and investment behavior systematically vary across demographic groups in a way that has important implications for economic inequality [11]. Lusardi's work, among others, has consistently documented that women, racial minorities, younger respondents, and persons with lower levels of educational attainment exhibit lower levels of financial literacy [12]. In the United Kingdom, an alarming trend is demonstrated by declining generational financial literacy, with only 9% of 18-24-year-olds passing a basic money literacy test compared with 23% of the general population. This generational knowledge gap is troublesome given that young adults also face increasingly complex financial decisions about student debt, retirement planning, and investing in volatile assets.

According to the various developmental perspectives on financial decision-making processes, it has been recognized that there are developmental patterns for the acquisition of financial knowledge and decision-making capabilities across a person's lifespan through various developmental milestones, from early childhood through early adulthood, so that basic financial concepts are acquired during middle childhood and advanced knowledge of investments is typically acquired in adolescence and early adulthood, as recognized and based on developmental perspectives by the Consumer Financial Protection Bureau [13][15].

Recent research has also started investigating the effect of cognition in old age on financial decision-making. WALLET, i.e., Wealth Accumulation and Losses in Later Life Early Cognitive Transitions, is research that analyzes the impacts of early memory loss on financial behavior, indicating that those experiencing early memory loss display significantly higher excess expenditures. This demonstrates the potential for exploitation and poor decision-making in old age, which have great implications for the importance of financial planning.



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### 2.4 Educational Interventions and Policy Responses

The documented deficiencies in financial literacy have spurred a variety of educational initiatives from multiple sectors. School-based financial education has gained momentum, with a growing number of U.S. states mandating personal finance coursework for high school graduation [14]. Research indicates that students who complete such courses demonstrate improved financial behaviors, including more prudent borrowing for college and reduced credit card debt.

Apart from formal education, employers, financial institutions, and community organizations have developed numerous programs in financial literacy [16][18]. However, the effectiveness of such interventions has remained mixed due to issues like inadequate training for instructors, lack of standardization in these programs, and difficulty ensuring retention over time. According to Lusardi, although the pace of financial education is accelerating, significant gaps exist in quality and accessibility [17].

A new generation of approaches focuses on behavioral-informed financial education that tackles knowledge gaps and cognitive biases alike. Instead of teaching financial concepts, these interventions incorporate insights from behavioral science to make individuals aware of their biases and also enable them to take measures to reduce those biases [19][20]. Such an approach recognizes the complex interplay between knowledge and psychology in financial decision-making

## III. METHODOLOGY

### 3.1 Research Design and Conceptual Framework

In this study, a mixed method is integrated by using quantitative methods for analyzing financial literacy tests and behavioral modeling of investment decisions. The research is based on the premise of a conceptual framework that recognizes the role of financial literacy as a first-order factor affecting behavioral determinants, demographics, and developmental phases to result in an investment outcome (as shown in Figure 1).

The framework engages elements of various theoretical perspectives:

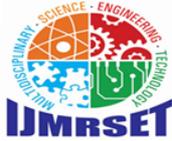
- **Human Capital Theory:** Financial literacy is seen as investment in human capital, which provides returns in terms of better decision-making in finance.
- **Behavioral Finance Theory:** Recognizes the occurrence of systematic deviations from rationality in financial choice and comprises cognitive biases as moderating factors.
- **Life Course Perspective:** This theory considers that financial decision-making capacity is not constant and can develop throughout the life stages.

### 3.2 Data Collection and Sample Characteristics

For the current study, primary data was collected through a structured questionnaire distributed among a diverse sample of individual investors. The sample consisted of 450 investors. The questions were designed and developed on the basis of existing measures such as:

- **The Big Three" Financial Literacy Questions:** Measuring knowledge of interest rates, inflation, and risk diversification.
- **OECD Financial Literacy Assessment:** Adapted to cultural considerations and involving elements of knowledge, behavior, and attitudes related to finance.
- **Behavioral Bias Scales:** Dimensions involved are heuristic bias, overconfidence, herd mentality, and framing effects.
- **Investment Decision Measures:** Assessing portfolio diversification, risk management, and investment performance measures.

The sample population was further stratified based on critical demographic factors: age groups, particularly young and older investors; gender; educational level; income level; and investment experience. More data were included through secondary sources, i.e., the WALLET study on financial decision making in older adults and national studies on financial literacy.



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Table 1: Sample Demographic Characteristics

Characteristic	Category	Percentage	Mean Score	Financial Literacy
Age Group	18-30	25%	58.2	
	31-50	40%	65.7	
	51-70	30%	62.1	
	70+	5%	59.4	
Gender	Male	52%	66.3	
	Female	48%	59.8	
Education	High School or Less	20%	54.1	
	College/University	65%	64.9	
	Graduate Degree	15%	73.2	
Investment Experience	< 2 years	30%	56.7	
	2-10 years	50%	64.5	
	> 10 years	20%	70.3	

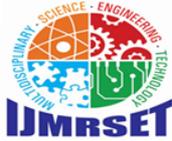
### 3.3 Analytical Approach: Decision Tree Regression Modeling

To examine the hierarchical relationship between variables which affect the investment decisions, this study utilized a Decision Tree Regression (DTR), which is a form of machine learning that can capture non-linear effects between variables. This is unlike linear models which assume additivity, whereas DTR uses recursive partitioning based on predictor variable values, similar to a tree-like diagram which captures variable interactions.

The process of modeling involved the following steps:

- Variable Selection:** Based on theories and previous studies, the relevant variables were selected – financial literacy, behavioral bias, demographics, and financial knowledge scores.
- Data Partitioning:** The dataset was divided into a set for training the model (70%) and a set for testing the model (30%).
- Tree Construction:** Using the Classification and Regression Tree algorithm, the model was able to find the best points to split in order to achieve homogeneity in the final groups produced by the model.
- Pruning:** In order to avoid overfitting, the tree was pruned, and cross-validation was performed to determine the optimal complexity.
- Interpretation:** The variable importance metrics were developed to measure the relative contributions of the individual predictors to the model.

The DTR approach will be specifically advantageous to this research question in that the decision pathways are visually depicted to make different combinations of financial literacy and behavioral factors lead to distinct investment outcomes. This corresponds well with the theoretical perspective taken in the study: it views investment decisions as emerging from complex interactions rather than simple linear relationships.



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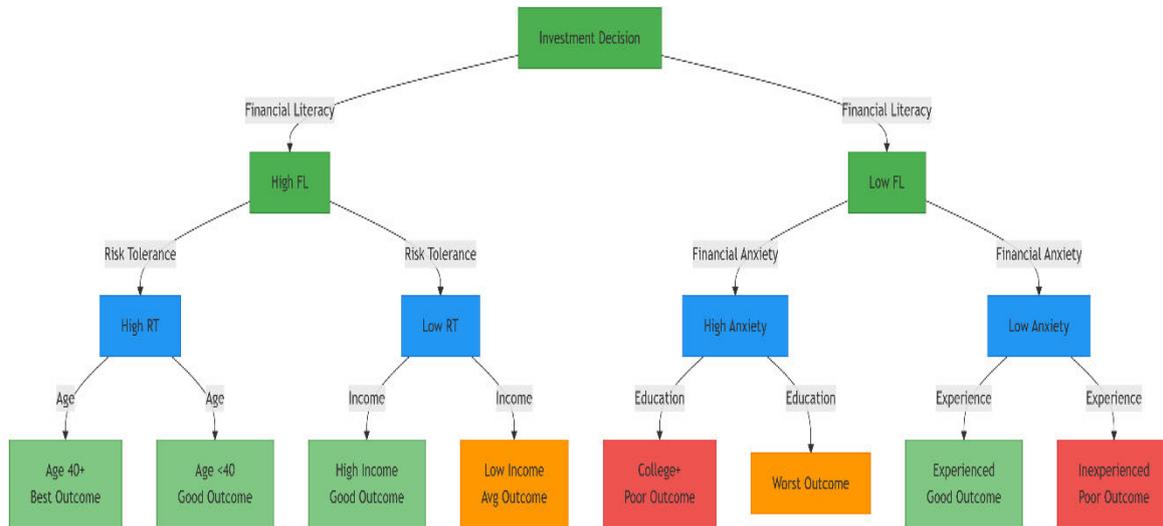


Figure 2: Decision Tree Regression Model Structure

### 3.4 Complementary Analytical Techniques

Besides DTR, several complementary analytical approaches were employed:

- **Structural Equation Modeling (SEM):** used in testing the proposed conceptual framework and reviewing both direct and indirect relationships that exist between financial literacy, behavioral biases, and investment outcomes.
- **Comparative Analysis:** The comparison of demographic subgroups in terms of financial literacy levels and investment behaviors to find out disparities that might suggest points of intervention.
- **Developmental Trajectory Analysis:** This would test the proposition that financial decision-making capacity changes with age, focusing on the early adulthood and older adulthood transition points.

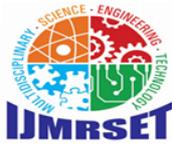
## IV. RESULT ANALYSIS

### 4.1 Financial Literacy Levels and Demographic Disparities

Consistent with previous research, this study found cause-for-concern levels of financial illiteracy across the sample. Only 31.2% of participants correctly answered all three basic financial literacy questions, showing particular difficulty on the inflation question (52% correct) and risk diversification question (44% correct). This result is consistent with Lusardi's national data showing a mastery rate of the Big Three questions at 28.5% and suggests that financial illiteracy remains prevalent despite increased attention to financial education.

In fact, there were significant demographic differences in the financial literacy scores:

- **Age Differences:** Contrary to expectations of financial knowledge building up with experience, the 31-50 age group had the highest financial literacy scores, with a mean of 65.7, while the youngest participants, aged 18-30, had the lowest scores, with a mean of 58.2. Older adults, 70 years and above, showed a decline to 59.4, probably reflecting cohort effects in financial education or cognitive aging factors.
- **Gender Gap:** There was a large gender gap; the scores of males were considerably higher than those of females, with means of 66.3 and 59.8, respectively. This difference of 6.5 points is roughly one standard deviation in the overall distribution.
- **Educational Gradient:** Financial literacy improved steadily and positively across levels of educational attainment, ranging from 54.1 for those having less than high school graduation, up to 73.2.
- **Experience Effect:** More experience correlated with financial literacy, and the highest mean, 70.3, was obtained by investment experience of over 10 years.



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### 4.2 Decision Tree Regression Findings

The Decision Tree Regression model also revealed a moderate predictive capability ( $R^2 = 0.185$ ; MAPE = 172.96%), suggesting that while financial and behavioral characteristics are significant predictors of investment decisions, much of the variation still remains to be explained. This observation also resonates with the behavioral finance theory suggesting investment decisions involve a level of idiosyncrasy and irrationality.

The hierarchy of the decision tree identified the attitudes towards investments as the first split factor, accounting for 25.88% of the determinant influence on the outcomes of the investments. This underlines the primary importance of the psychological aspect of the attitude to investments, which requires to be incorporated into the educational process.

**Table 2: Variable Importance in Investment Decision Prediction**

Variable	Importance Percentage	Interpretation
Investment Attitudes	25.88%	Psychological orientation toward investing as primary driver
Decision-Making Behaviors	19.53%	Systematic approaches to investment choices
Financial Education	16.68%	Formal and informal learning experiences
Speculative Investment Attitudes	12.45%	Willingness to engage in high-risk, high-reward investments
Trust in AI-Based Financial Systems	8.92%	Comfort with algorithmic investment tools
Resilience After Financial Losses	7.31%	Ability to recover from investment setbacks
Age	5.24%	Developmental and cohort effects
Income	3.99%	Financial resources available for investment

The variable importance analysis brought forth a number of interesting results that contradict traditional thinking on investment decision-making. Firstly, conventional demographic factors like income (3.99%) and age (5.24%) have relatively lower predictive significance compared to behavioral and attitudinal factors. This asserts the relevance of behavioral and attitudinal factors vis-à-vis socio demographic factors. Secondly, the incorporation of "Trust in AI-Based Financial Systems" (8.92%) as one of the key factors further substantiates the increasing impact of financial technology on investment decisions, particularly among the younger generation. Thirdly, moderate importance ratings like "Resilience After Financial Losses" (7.31%) emphasize the emotional aspect of investment decisions.

The decision tree structure identified several distinct profiles of investors based on different combinations of predictor variables:

1. **The Educated Conservative:** High financial education accompanied by low speculative risk tolerance, meaning systematized decision-making and higher-than-average portfolio diversification.
2. **The Speculative Optimist:** Indicates high investment sentiments along with high speculative levels, implying high portfolio concentration as well as trading frequency.
3. **The Technology-Dependent:** Highly trusting AI systems with moderate financial literacy, suggesting dependence on algorithmic recommendations that yield varying results.
4. **The Experience-Based:** Less formal educational attainment, heavy investment knowledge, and sometimes an ability to compensate for a lack of knowledge through experience.

### 4.3 Financial Literacy's Impact on Investment Behaviors

Participants who scored higher in financial literacy demonstrated different investing behavior compared to those who scored lower:



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**Table 3: Investment Behavior by Financial Literacy Level**

Investment Behavior	High Literacy (Top Quartile)	Low Literacy (Bottom Quartile)	Statistical Significance
Portfolio Diversification (Herfindahl Index)	0.32	0.58	$p < 0.001$
Annual Portfolio Turnover Rate	45%	82%	$p < 0.01$
Emergency Fund Establishment	92%	63%	$p < 0.001$
High-Interest Debt Carried	18%	47%	$p < 0.001$
Retirement Account Participation	88%	52%	$p < 0.001$
Alternative Investment Allocation	22%	8%	$p < 0.05$

They held more diversified portfolios, as evidenced by their high degree of diversification based on their Herfindahl Index of 0.32 relative to 0.58 for low financial literacy investors. They also evidenced a lower portfolio turnover of 45% annually compared to 82% for low financial literacy investors, perhaps underscoring their expected behavior of less trading in line with market movements, a practice expected to drive down their costs of trading and hence increase their potential investment returns. However, perhaps more interestingly are the key differences with respect to the fundamental investment planning practices in place, where 92% of financially literate investors held emergency reserves compared to 63%, 18% had high-interest debt compared to 47%, and 88% held retirement plans compared to 52%.

#### 4.4 Behavioral Biases as Moderators

The relationship between financial literacy and the outcome of the investment process was significantly moderated by behavioral biases, with overconfidence exhibiting complex influences.

Overconfidence is known to be linked to unfavorable investment decisions despite the complexities it portrayed in the favorable outcomes linked to financially literate knowledgeable investors, as well as the negative outcomes for those with limited knowledge.

This is supported by the study focusing on the Palestinian investors, where it demonstrated how overconfidence strengthens the relationship between financial literacy and the investment decision process.

Other behavioral biases had uniformly negative effects:

- **Herd Mentality:** The benefits of financial literacy were also reduced, including reduced performance attribution for herding investors regardless of their knowledge status.
- **Framing Effects:** Reduced the application of financial knowledge, as the investors exposed to the framing effects made contradictory decisions, despite their proper understanding of financial principles.
- **Heuristic Bias:** Particularly damaging for investors with moderate financial literacy, who were unaware of an inability to come to an educated decision, lacking cognitive awareness of these decision-making shortcuts.



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Interaction Effects Between Financial Literacy and Behavioral Biases  
3D Surface Plot of Investment Performance

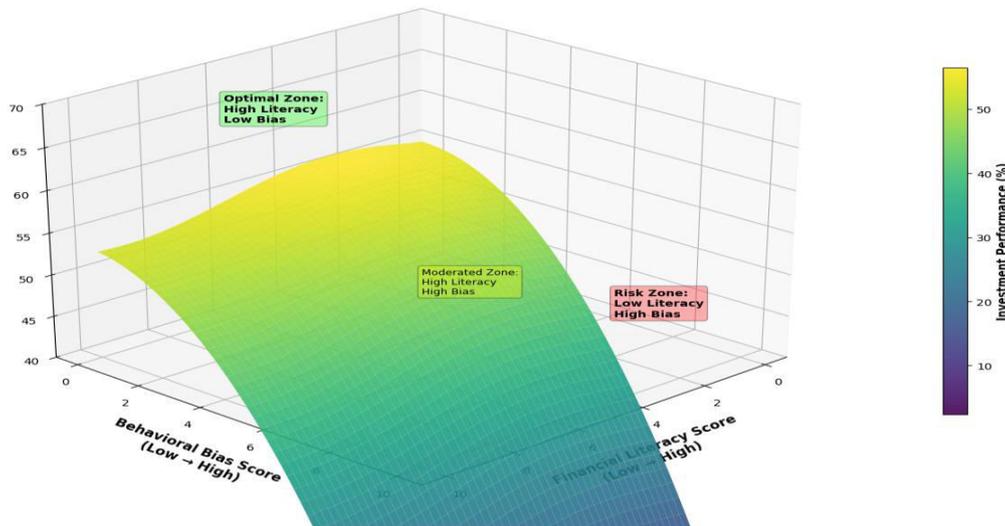


Figure 3: Interaction Effects Between Financial Literacy and Behavioral Biases

### 4.5 Developmental Perspectives Across the Lifespan

Financial decision-making capacity was also analyzed across various age groups, which indicated unique developmental trends. It was observed that young investors, belonging to the age group of 18-30, possessed sufficient theoretical knowledge, but the level of practical application was insufficient, especially with respect to long-term financial planning and risk assessment. This is also evidenced by UK research, which reported that only 9 percent of the 18-24 age group make the grade in a financial literacy test. Middle-aged investors, belonging to the 31-50 age group, displayed the highest level of financial decision capacity, whereas aged investors displayed divergent trends, both positive and negative.

- The WALLET study findings on excess spending among individuals who experience early memory decline were also reflected, to a certain degree, within this sample, showing that older adults were more susceptible to various behavioral biases, especially framing effects and heuristic simplification. This could support the existence of an inverted U-shaped curve for financial decision-making capacity, where development, optimal function, and possibly decrement occur across life span and cognitive preservation into late life.

## V. CONCLUSION

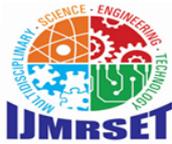
This research delivers an integrated approach to the investment decision-making process, combining elements of literacy, behavior, and development. The key findings provide evidence for critical implications.

### 5.1 Theoretical Contributions

The study makes three primary theoretical contributions to the literature in financial decision making:

First, it illustrates the hierarchical nature of financial investment decisions in which psychological elements (investment attitudes and financial decision-making behaviors) dominate the effects of conventional demographic and economic factors. This contradicts classical finance theories emphasizing rational calculation in financial decision-making and the need for behavioral theories of finance.

Second, this involved an understanding of the moderating effect of behavioral biases on the relationship between financial literacy and investment outcomes. It was noted that biases such as overconfidence may actually enhance both positive and negative influences depending on the level of financial knowledge of the investor. This understanding goes a step further than simple "biases-as-error" approaches.



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Third, it incorporates a developmental perspective into investment decision-making, thereby showing the existence of distinct patterns of capabilities during the life span. The peak observation in the middle age, which may correspond to declining health with cognitive aging, expands life span theories to the domain of finance while also showing potential weaknesses at both extremes of age.

### 5.2 Practical Implications

The findings have several practical implications for financial educators, policymakers, and investment professionals.

1. **Targeted Educational Interventions:** Financial education programs should address both knowledge gaps and psychological issues while utilizing behavioral insights to assist investors in understanding and managing their own biases. Interventions should be targeted toward different investor profiles as distinguished through decision tree analysis.
2. **Developmental Sequencing:** Financial education developmentally refers to the order in which information is provided, as children learn the core concepts in childhood, young adults focus on application, and elders are encouraged to preserve.
3. **Demographic Prioritization:** Specific groups that lag behind in literacy standards, women, younger people, less-educated individuals, need to be targeted.
4. **Regulatory Considerations:** In framing financial regulation, it is important to recognize the relevance of cognitive biases through appropriate presentation formats.
5. **Technology Integration:** As trust levels are being built in AI-based financial systems, transparency in algorithms and educating investors about the limitations of technology are important issues to consider.

### 5.3 Limitations and Future Research Directions

This study has several limitations, which suggest avenues for future research. The cross-sectional design has the basic limitation of precluding causal inferences between financial literacy, behavioral factors, and investment outcomes. Longitudinal studies that track investors over time will yield much stronger evidence of the dynamic interaction among these factors.

With the moderate predictive power of the decision tree model-which explained a fairly small portion of variance,  $R^2 = 0.185$ -it is indicated that substantial variance in investment decisions remains unexplained. Therefore, future research should investigate additional predictors including genetic factors, personality traits, cultural influences, and social networks that may influence financial behavior.

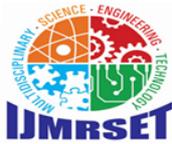
Although the sample is diverse, it may not fully represent all the investor populations. Generalizability would be strengthened by replication across different cultural and economic contexts. Besides, relying on self-reported measures of some variables introduces potential biases in responses that objective measures might avoid.

Future research should also be conducted on the relative efficacies of various educational interventions, especially those that combine behavioral insights with financial knowledge. Experimental investigations that match traditional financial education against behaviorally-informed approaches may determine what works best in enhancing real-world financial decision-making.

### 5.4 Policy Recommendations

On the basis of the findings, it is recommended that:

1. **Universal Financial Education:** Implement a comprehensive and mandatory financial education scheme in the school system based on developmental appropriateness guidelines, paying particular attention to the gender gap in financial literacy.
2. **Workplace Financial Wellness Programs:** Incentivize the adoption of financial education programs focusing on the interplay of knowledge and behavioral aspects, acknowledging the importance of productivity gains from financial stress reduction.
3. **Cognitive Aging Protections:** Establish various regulations to protect older investors, including disclosure requirements and cooling-off periods for important investment decisions, along with training content for financial professionals on detecting signs of cognitive aging.
4. **Technology Governance:** Set standards for AI-based financial tools to ensure transparency, avoid exploiting behavioral biases, and promote algorithmic fairness.



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- National Financial Literacy Assessment: Establish the standard assessment of the level of financial literacy of different demographic groups of the population.

In conclusion, this research highlights the fact that investment decision-making is a function of a very complex interplay of knowledge, psychology, development, and demographics. If we are to improve financial outcomes and decision-making processes, this can be achieved by a more integrated and holistic approach beyond the simple confines of the construction and conveyance of knowledge.

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