Constructs of Curiosity and Interest: Qualitative and Quantitative Investigations

Thesis submitted for the degree Doctor of Philosophy

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Declaration: I confirm that this is my own work and the use of all material from other sources has been properly and fully acknowledged.

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“[...] the curious or impatient soul
That in the start, demands the end be shown,
And at each step, stops waiting for a sign”
— Ella Wheeler Wilcox: Consciousness

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Abstract

Curiosity and interest have long been a topic of psychology and education and there is no consensus about their conceptualizations, mechanisms and measurements. A contemporary work on curiosity treats information-seeking as reward learning; likewise, recent work on interest has also emphasized the importance of rewarding feeling. This led researchers to consider curiosity and interest in the common scheme called a reward learning framework of knowledge acquisition. The purpose of the current dissertation is to examine the similarity and differences of curiosity and interest based on this framework, using both qualitative and quantitative methods. The first study (Chapter 2) examined people's naïve beliefs about curiosity and interest. The results showed that while curiosity was considered to be active feelings towards uncertainty, interest was considered to be a more stable feeling than curiosity, which was more oriented towards certain things. On the other hand, curiosity and interest had a substantial overlap on knowledge acquisition process. The second study (Chapter 3) developed a new Curiosity and Interest as Rewarding Feeling scale (CIRF). The final 9-item scale showed a good fit with a single factor model, indicating that it may not be necessary to distinguish curiosity and interest when assessing the rewarding feeling caused by knowledge acquisition. In the last studies (Study 3a and Study 3b; Chapter 4), we tested the construct validity of CIRF by examining the relationship of the newly developed scale with other relevant scales. Overall, the developed scale demonstrated the pattern of relationships consistent with the predictions. These studies underscored the complex relationship of curiosity and interest during the knowledge acquisition process in the reward learning framework. Critical evaluations have been included in the last chapter, which drew a broader conclusion in the interaction between curiosity and interest during knowledge acquisition process and also discussed some implications.

Contribution Statement

I (SA) was the lead researcher for all research reported in the chapters included in this thesis, although I have often used the term "we" in the thesis to acknowledge the joint effort of my collaborators. With regular input from my supervisors who are Prof Kou Murayama (KM) and Dr Dan Jones (DJ), I led planning for each of the chapters, data collection and data analysis. I submitted and revised ethics applications and wrote first drafts of each paper. My contribution and other researchers' contribution to each chapter are outlined below.

Chapter 1: Introduction

I developed the conceptual framework and the outline of the thesis under the supervision of Prof Kou Murayama. I led planning for the literature review and revised the research questions. I wrote the first draft of the manuscript and revised it after receiving feedback from KM.

Chapter 2: Qualitative Study

I led planning for the qualitative study, including designing the research question. I regularly discussed these issues with KM, DJ and we did critical edits with Edmund Donnellan. Greta Fastrich supported me how to use the study on MTurk. I also planned and led the data collection for qualitative study. I also transcribed and coded all qualitative interviews. I developed preliminary themes, and revised them during meetings with KM and DJ. I wrote the first draft of the manuscript and revised it after receiving feedback from co-authors.

Chapter 3 and Chapter 4: The development of the new scale and the validity study of the new scale

I led the development of the study's protocol, including the research question, data collection strategy and data analysis plan, and regularly discussed all of these matters with KM. I contacted schools, applied the questionnaires, and led the statistical analyses. I regularly discussed study results with KM. I wrote the first draft of the manuscript and revised it after receiving feedback from KM.

Chapter 5: General Discussion

I led planning for the summary of findings, critical evaluation, implications, and limitations. I wrote the first draft of the manuscript and revised it after receiving feedback from KM.

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1 Chapter 1: Literature Review

1.1. Introduction

How are Curiosity and Interest defined in literature?

Curiosity is described in various ways by a variety of disciplines in psychology and education (e.g., the desire to know, Berylne, 1960; exploratory behaviour, Pavlov, 1927; an appetite such as hunger, Schimitt & Lahroodi, 2008). It is a crucial phenomenon in order to understand consciousness and human behaviour (Berlyne, 1954, Loewenstein, 1994; Pavlov, 1927). Interest, as defined in the field of education, is a psychological state that involves a different type of information-seeking to trigger new questions for the development of learners' knowledge and value (Hidi & Renninger, 2019; Hidi & Renninger, 2020). Thus, the concepts of curiosity and interest have both received increasing attention in the literature of motivation and education (Renninger & Hidi, 2016). For instance, curiosity has been shown to positively affect learning outcomes and processes (Arnone et al., 1994). Curiosity is also related to higher academic performance on standardized tests (Wavo, 2004) and academic persistence (Smalls et al., 2007). Likewise, interest supports learning within a particular person and content relation (Renninger et al., 2002) and has been shown to facilitate cognition and affect as a motivational variable that aids attention (Hidi, 2000). Despite an increasing amount of work on these topics in recent years, a critical issue remains in the field that is a lack of consensus on how to conceptualize curiosity and interest (Ainley, 2019; Brick et al., 2020; Donnellan et al., 2021; Grossnickle, 2014; Loewenstein, 1994; Silvia, 2006). Although some researchers suggest that it is not necessary to differentiate between curiosity and interest to progress the field (Kidd & Hayden, 2015; Murayama et al., 2019), inconsistent use of the language may hinder effective scientific communications among researchers (Grossnickle, 2014; Reio et al., 2006). In addition, thinking about the definitions of these terms may shed new light on the psychological processes underlying effects of curiosity and interest.

In the classical literature, curiosity has been explained within the framework of drive reduction theories, similar to an appetite (analogous to other primary needs such as hunger, Berylne, 1954). Further, it is proposed that curiosity is the pleasant experience of novelty seeking and, as such, is an optimal arousal state lying in between feelings of anxiety and boredom (Spielberger & Starr, 1994). Additionally, Loewenstein (1994) describes curiosity as associated with the identification of unknown pieces of information (i.e., knowledge gap: see Section 1.2.4). Another approach states that a dynamic subsystem regulates attentional focus through a spontaneous learning process, thus curiosity is part of a larger unconscious mechanism (Iran-Nejad, 1990).

Similar to research on curiosity, there have been different perspectives on how interest is conceptualized and theorized. For example, the four-phase model of interest development, one of the most prominent interest theories in the literature, supposes that there are four phases in the development of interest: (1) triggered situational interest; (2) maintained situational interest; (3) emerging individual interest; and (4) well-developed individual interest (Hidi & Renninger, 2006). The distinction between situational interest (1 & 2) and individual interest (3 & 4) is critical to the model. Situational interest is conceptualized as focused attention triggered by environmental stimuli, individual interest is conceptualized as a predisposition for reengaging with a particular topic (see Section 1.3.1). Another approach is Person-Object Theory of Interest which is developed by Krapp (2002). The researcher conceptualizes interest by connecting it to the person's growing awareness of the self. A critical element in his conceptualization is integrating oneself and the activities which one is interested in. Besides, the Expectancy-value Theory (Eccles et al., 1983; Wigfield & Eccles, 1992) examines task interest by considering the influence of the subjective value of certain activities on motivation and achievement in school. Interest is generally examined by considering individual differences in engagement with educational activities and motivation. Another prominent

model of interest, the self-regulation of motivation model (Sansone & Thoman, 2005), conceptualizes interest as a resource for self-regulation and focuses on people's ability to self-generate interest.

Previous studies have provided evidence of curiosity and interest as the most important motivating factors in education and psychology when learning or discovering something new (Singh & Manjaly, 2022; Tang & Salmela-Aro, 2021; Wolbert & Schinkel, 2020). However, while existing theories have discussed a variety of aspects concerning curiosity and interest, there is still no consensus in terms of how one can (or cannot) differently conceptualise the constructs, nor how one can (or cannot) assess them separately. This lack of consensus is unfortunate, as poor conceptualisations make it difficult to scientifically examine the importance of said constructs. As it is believed that conceptualising curiosity and interest separately misses an important opportunity to understand the learning process, this dissertation seeks to discuss the distinctions between curiosity and interest, while also highlighting the commonalities, and clarifying both similarities and differences between them. The aim is to encourage researchers to study the phenomenon from new pedagogical and motivational perspectives. The following sections present the aspects of differences that have been examined, along with theories in terms of their definitions and measurements.

1.2.Curiosity

A considerable amount of the literature with different perspectives on curiosity is examined here, aiming to understand the nature of curiosity. Curiosity theories focus on the multidimensionality of human experiences and the gaining of information (Berlyne, 1960; Litman, Collins & Spielberger, 2004; Litman & Jimerson, 2004; Litman & Spielberger, 2003; Loewenstein, 1994; Markey & Loewenstein, 2014). Curiosity has been generally related to an intrinsically motivated desire for information, a passion for learning, an appetite or thirst for

knowledge (Loewenstein, 1994). The theories of curiosity have been explained through drive, optimal arousal, and knowledge-gap models, which are discussed below (FitzGibbon et al., 2019; Hsee & Ruan, 2016; Loewenstein 1994; Oosterwijk, 2017).

1.2.1. Is Curiosity a Drive or a Trait?

The nature of curiosity has often been explained in psychology as a drive (e.g., urge, hunger, appetite) to understand an environment, frame questions, and find answers to the survival of humans (Berylne, 1966; Blumenberg, 1983; Markey & Loewenstein 2014). Berylne (1954) presents curiosity in two dimensions: *perceptual* and *epistemic* curiosity. Perceptual curiosity is explained as a drive aroused by novel stimuli and exploration through these simulations (e.g., visual or auditory viewing) for knowledge acquisition; while epistemic curiosity refers to a desire for knowledge (Berlyne 1954; Litman and Spielberger 2003). Berylne also defined *specific* and *diversive* curiosity respectively as resolving unknown pieces of information (i.e., reducing uncertainty) and as increasing arousal or decreasing boredom (i.e., seeking uncertainty) (Grossnickle, 2014). Even though Berlyne attempts to explain curiosity by together focusing on drive and the desire to know, specific and diversive curiosity highlight epistemic curiosity. Therefore, Mussel (2010) indicates that epistemic curiosity could be distinguished by labelling it as both specific and diversive. Measuring epistemic curiosity in its specific and diversive components was found to be highly correlated on these two dimensions (see Litman & Spielberger, 2003). Additionally, ideas about specific/diversive curiosity show similarities with breadth/depth of curiosity, as defined by Loewenstein (1994). Breadth curiosity refers to the curiosity of an individual on many different topics, areas of knowledge, and experiences (diversive curiosity); whereas depth curiosity focuses on the sustainability of a limited number of topics (specific curiosity) (Grossnickle, 2014; Loewenstein, 1994). Indeed, curiosity is also treated as a standard homeostatic drive (i.e., a

maintainable and stable internal state, like appetite, sexual desire) to fill the information gap (Shin & Kim, 2019).

A further theory proposes two types of curiosity: The theory of state-trait curiosity suggests that curiosity is a personality trait (i.e., trait curiosity) as well as a more temporary state caused by environmental triggers (i.e., state curiosity). It predicts that a high trait level in an individual would show more intensive feeling in the momentary experience of curiosity compared to individuals with a low trait level (Litman & Silvia, 2006; Kashdan et al., 2004; Spielberger, 1979). In 1960, Berylne connected state curiosity with the collative variables (i.e., uncertainty, surprisingness, novelty, and complexity), which generate imbalance and a state of arousal for individuals (Grosnicckle, 2014). The collative variables are examined as triggers for an individual's curiosity and are conceptualised with this theory on further dimensions such as joyous exploration, deprivation sensitivity, thrill seeking, social curiosity, stress tolerance of the dimensions of trait curiosity (Kashdan et al., 2018). Researchers have also developed state-trait measurements (see Section 1.6). For instance, trait curiosity measurements have been utilized by organizations (Job performance, Harrison, et al., 2011). Overall, state curiosity lets us explore environmental triggers; trait curiosity highlights personality types, and this approach is consistent with myriad personality scales (e.g., novelty seeking, Cloninger et al., 1993; sensation-seeking, Zuckerman, 1979).

Although the various theories about curiosity as a drive are not unified into one theory, researchers have evaluated connections such as information-seeking, knowledge acquisition, motivation and environment within the sphere of curiosity. Regarding state and trait curiosity, this theory emphasises environmental triggers and changes in personality type along with curiosity. Grossnickle (2014) indicated that state curiosity presents greater promise than either diversive curiosity or trait curiosity. While diversive curiosity is associated with boredom and sensation-seeking (unlike the conventional meaning of curiosity), measuring curiosity as a trait

might be a fundamental problem. Since the reduction of curiosity as a drive and a trait has supported an understanding of the concepts of curiosity, these theories have features that compliment curiosity. In the light of Grossnickle's findings, the psychological mechanism of curiosity might be focused on motivation during the learning process.

1.2.2. The Strong Motivating Power of Curiosity

Curiosity is a strong motivating factor that tends us intrinsically and constantly to learn or explore something. It is examined as interest and deprivation in terms of wanting and liking motivator. At the trait level, curiosity as a feeling of interest and deprivation refers to the desire to know and seek information based on epistemic curiosity (Litman & Jimerson, 2004). The feeling of interest (I-type curiosity) supplies the exploration of new knowledge to feel pleasure, whereas the feeling of deprivation (D-type curiosity) corresponds with the intensity of finding immediately unknown information to decrease feelings of uncertainty (Litman & Jimerson, 2004). The intensity of curiosity might be the result of the positive and negative feeling of having novel information or bridging the knowledge gap. Both state/trait curiosity and I/D-type curiosity theories propound the individuality of curiosity by showing the variation of curiosity in terms of personality forms and the feelings for knowledge acquisition. Additionally, Litman (2019) attempts to emphasize interest as a liking component and deprivation for wanting in curiosity. Wanting is a trigger in curiosity; whereas interest for liking is considered commonly in a sustainable process during knowledge acquisition (FitzGibbon et al., 2020; Donnellan et al., 2021; Wong et al., 2020). Thus, these curiosity theories emphasize the experiences, environment and diversity of human personality and feelings when acquiring or seeking information.

So far, the desire for new knowledge has been the core term in theoretical definitions of curiosity (Bowler 2010; Litman & Silvia 2006). A contemporary approach to curiosity has emphasized a special form of information-seeking which is internally motivated (Kidd &

Hayden, 2015; Loewenstein, 1994; Oudeyer & Kaplan, 2007). According to this view, curiosity is an intrinsic drive, yet information-seeking is a general drive that can be either intrinsic or extrinsic. For example, paying for a gamble to know the outcome and to gain a profit is an instance of extrinsic information-seeking, but individuals' strategic and immediate information-seeking could also be influenced by intrinsic motivation (Kidd & Hayden, 2015). Another example could be children's exploratory behaviour when trying new things. It is difficult to observe whether their decision is made intrinsically or extrinsically (Murayama et al., 2018; Lowenstein, 1994). Along with this information, Lowenstein's knowledge gap theory suggests that a piece of information is assumed as a trigger of curiosity. Knowledge acquisition is a rewarding experience and when individuals feel they have absorbed enough information, satiation emerges. Then, information assists in reducing further curiosity (Kidd & Hayden, 2015; Loewenstein, 1994; Oudeyer & Kaplan, 2007).

In order to shed light on this theory, Kang et al., (2009) proposed that curiosity is an inverted U-shaped function of confidence, with individuals presenting the most curiosity for topics that they were moderately confident about. For example, when an individual is curious about the answer to a trivia question, the U-shaped function of confidence about knowing the answer means that if the individual does not have a hint about the answer, they are less curious, but extremely confident. If they have some thoughts about the answer, they are most curious and less confident (Kang et al., 2009; Kidd & Hayden, 2015; Murayama et al., 2018). Therefore, when the topic is too novel for the individual or not novel at all, curiosity will not occur. The evidence presented in this section suggests that this theory has supported curiosity research towards information-seeking phenomena, knowledge acquisition, and feelings of reward.

When evaluating curiosity on knowledge gap and information-seeking, curiosity could be seen as a motivation to figure out an information gap related to individuals and their prior

knowledge (Litman, 2019; Loewenstein, 1994; Shin & Kim, 2019). Exploratory behaviours (e.g., completing a script in a mystery novel, finding out the winner of an election or athletic event, solving puzzles) enhance curiosity as a motivational factor when seeking out knowledge or new experiences (Berlyne 1954; Kashdan et al., 2009; Loewenstein 1994). For example, people seek information if the benefit of solving curiosity is more than the cost (see cost-benefit analysis, Shin & Kim, 2019). Besides, the intensity of motivated information-seeking behaviour is connected to the expected reward value of having the information (Murayama et al., 2019). The aim of curiosity could be to close the information gap after finding the specific information (Donnellan et al., 2021; Markey & Loewenstein, 2014). Overall, curiosity might lead to active information-seeking behaviour to find or explore a knowledge gap and a piece of specific information.

Another point of curiosity research with regard to information-seeking is the type of questions asked during the knowledge acquisition process. Noted by Shin and Kim, (2019), forward and backward curiosity provides two different forms of curiosity; the former is relevant when checking the accuracy of your guess (forward curiosity) and the latter is relevant when one is wondering about the reason for your unexpected result (backward curiosity). This perspective is discussed in the context of discussing the difference between curiosity and situational interest, the latter of which is defined as temporary interest that is triggered by environment, such as playing a brief piece of music in class by a teacher (see more detail for situational interest Section 1.3.1). The purpose of situational interest tends to be positive experience or enjoyment, whereas curiosity focuses on actively seeking specific information for either knowledge acquisition or the dissipation of curiosity (Donnellan et al., 2021; Grossnickle, 2014; Renninger & Hidi, 2016; Shin & Kim, 2019; Silvia, 2005). Grossnickle (2014) addressed momentary and enduring forms regarding the conceptual confusion between situational interest and curiosity. Despite their similarities about triggers and conditions in their

transient states, curiosity and situational interest present remarkably different characteristics during the knowledge acquisition process. Knowledge acquisition process along with information-seeking behaviour has been the main focus of curiosity and interest theories; but recently adding to this focus is reward feeling or value for knowledge and neurological reward systems (Dayan & Niv, 2008; Montague & Berns, 2002; Murayama et al., 2019) as further discussed in Section 1.2.3.

Curiosity is also associated with decision-making (FitzGibbon et al., 2020; Ozkara et al., 2016). Decision-making models are generally based on the motivated activation of knowledge stored in memory, or knowledge acquisition from the environment (Engel et al., 1995). Baharlou (2017) put forward a model of curiosity in decision-making based on the information gap theory of Loewenstein. The model generates groundwork to determine choice in two choice environments: discovery and no discovery. For example, a decision-maker (DM) chooses a restaurant among three restaurants (*a, b, c*) and the DM has tried *a* before. The DM chooses *a* because of familiarity but when offering only *a* and *c*, the DM then chooses the untried *c* (Baharlou, 2017). The role of curiosity is postulated over this example during the decision-making process of the DM by exploring alternatives in the model. According to Loewenstein's theory, it includes two core implications: the first is the intensity of curiosity for a particular item of information which needs to be positive to solve uncertainty/close the information gap; and the second one is that curiosity needs to be positive in relation to the DM's knowledge in a particular domain. Curiosity rises as a result of the existence of an information gap when the DM focuses on unknown information, rather than what the DM knows, and the DM considers the alternatives regarding the lack of information in the constraint set under consideration. Thus, the reference point depends on the information gap instead of the DM. Yet, there are limitations and extensions to improve the model; for example, the presence of curiosity is either active or not as a binary variable. It would be beneficial that

if the intensity of curiosity would be generalised as continuous to show the effect of curiosity (Baharlou, 2017). Most importantly, along with the information-seeking phenomena of curiosity, this model supports to understand curiosity as a reference-point phenomenon under the knowledge-gap theory.

Decision-making studies on curiosity have been made in other subdisciplines of psychology. For instance, in neuroscience, the activation of subcortical brain areas toward decision-making, based on both food cues and curiosity-inducing cues, reveal a motivational role for both food and knowledge acquisition (Blanchard et al., 2015; Bromberg-Martin & Hikosaka, 2009; FitzGibbon et al., 2020; Kang et al., 2009). Even if the nature of curiosity in decision-making could not be settled clearly, it is still obvious that curiosity is connected with core drives in the decision-making process. These studies have contributed the mechanism of curiosity in the decision-making process by regarding it as protecting the variation of uncertainty, intensity and variables individually in a decision (Engel et al., 1995).

Curiosity as a motivator has remarked with its common simple qualifications, which are transience, impulsivity and intensity (Grossnickle, 2014; Loewenstein, 1994). Besides, curiosity theories comprise collative variables (e.g., uncertainty, surprisingness, novelty, and complexity as defined by Berlyne, 1960) in terms of the transience, impulsivity and intensity of curiosity from an information-seeking perspective (e.g., specific curiosity refers reducing uncertainty by knowing a specific piece of unknown information; Engel & Randall, 2009; Kashdan & Yuen, 2007). From incongruity theories (e.g., Hebb, Piaget and Hunt from the different accounts such as neuroscience, developmental psychology and motivation, respectively), curiosity reflects a natural human tendency in seeking subjective incongruency in the knowledge. However, this tendency makes the system unstable and often leads to expectation violations (Loewenstein, 1994). Also, an inverted-U shape curve is seen among evoked curiosity and the violation of extreme expectations as discussed above (Loewenstein,

1994). While the incongruity theories examine transience, impulsivity and intensity of curiosity with the violation of expectations, Litman and Jimerson (2004) attempt to explain the interest/deprivation feeling of curiosity based on epistemic curiosity, especially for the intensity and impulsivity of curiosity in terms of wanting and liking feeling (see Section 1.2.3). As for curiosity transience, it is associated with attention in curiosity because curiosity is the result of an attention of information gap and when individuals' attention is distracted, curiosity will typically finish (Loewenstein, 1994). The link between curiosity and attention separates curiosity from homeostatic drives (e.g., hunger, thirst) because after temporary distraction from these drives, individuals will feel intensely unsatisfied. The information gap perspective explains these three qualities of curiosity: the power of surprise in curiosity practices, optimal knowledge gap, and the value or cost of information-seeking behaviour also play significant roles on these qualifications (Shin & Kim, 2019). For instance, neuroscientists and behavioural studies researchers embrace information as a reward on dopaminergic systems, which is the process of primary rewards by activated curiosity, responding to novel or surprising experiences (Blanchard et al., 2015; Bromberg-Martin & Hisoka, 2009; Kang et al., 2009; Oudeyer et al., 2016). Research on the transience, intensity, and impulsivity of curiosity have supported the use of curiosity theories effectively in the fields of neuroscience, motivation, and education.

1.2.3. The Rewarding Value of Curiosity

Curiosity might also be explained by considering reward value and incentive salience during knowledge acquisition. While curiosity is evaluated as a motivated behaviour with the drive reduction approach, modern theories regard this as incentive salience as defined by strong urges or feeling of craving (Berridge, 2004; Dickinson & Balleine, 2002; Kang et al., 2009; Loewenstein, 1994; Murayama et al., 2019). The incentive salience learning model focuses on

liking (i.e., hedonic experiences or subjective feelings for rewards) and wanting (i.e., as an incentive salience is triggered during the expected reward value) (Berridge, 2004; Berridge, 2007; Berridge, 2012; Tedeschi, 2020). Likewise, Litman (2019) emphasized the interest/deprivation type of curiosity as liking/wanting in curiosity (See Section 1.2.2) and the knowledge gap theory indicated the consumption of information as a rewarding feeling (Kang et al., 2009; Loewenstein, 1994). Curiosity is also connected with knowledge acquisition in order to have extrinsic and intrinsic reward, which is naturally information-seeking behaviour (Loewenstein, 2014; Shin & Kim, 2019; Murayama et al., 2019). Therefore, reward feeling in curiosity has been examined both in the learning process and as a driving force primarily for survival (Kim, 2013). Collectively, the importance of reward value in curiosity has been noted in the literature of cognitive science, education and neuroscience (Ainley & Hidi, 2014; Gruber et al., 2014; Kang et al., 2009; Kidd & Hayden, 2015; Murayama et al., 2010; Sakaki et al., 2018; Hidi, 2016; Renninger & Hidi, 2016).

Another important discussion regarding curiosity is intrinsic motivation (Loewenstein, 1994; Murayama et al., 2019; Oudeyer et al., 2016; Murayama, 2018; Renninger, 2000; Murayama et al., 2019). In the literature, intrinsic motivation is defined as experiencing an activity as its purpose (Woolley & Fishbach, 2018), engaging with an activity due to the individuals' interest and pleasure without external possibilities, and strongly inseparable connection between the activity and its outcome (Garon-Carrier et al., 2016). Self-determination theory focuses on intrinsic motivation by considering the degree of an individual's perception regarding the fulfilment of their needs by including their autonomy, and the degree to feeling their effectiveness in an activity (Garon-Carrier et al., 2016). In the learning process, the satisfaction of the needs of autonomy and competence supports the reinforcement of intrinsic motivation and achievement. An individual's persistence on a task increases to sustain and more likely to achieve the task with intrinsic motivation (Garon-Carrier

et al., 2016; Murayama et al., 2017; Wooley & Fishbach, 2018). When looking at the connection between intrinsic motivation and curiosity, the theoretical perspectives reflected curiosity as salient and intrinsically motivated behaviours (see Section 1.2.2 for further discussion). From a competence perspective, curiosity is seen as the result of motivation by using an individual's unique environment within the competence motive, which supports individuals with curiosity to see their own abilities (Loewenstein, 1994). Even if the aim of curiosity does not often show the desire to achieve competence, Donnellan et al. (2021) state that curiosity appears naturally as an intrinsic motivation in people's evolutionary and developmental processes.

1.3. Interest

Interest is a fundamental human function which supports the massive variety of human intellectual behaviours, from learning in childhood to scientific exploration (Murayama, 2021; Renninger & Hidi, 2016). Interest is characterized as a critical cognitive and motivational variable that provides attention (Hidi, 2000; Krapp, 2007; McDaniel et al., 2000; Renninger & Hidi, 2011; Renninger & Wozniak, 1985; Schaeffner & Schiefele, 2007; Silvia, 2005;). Silvia (2008) described the knowledge emotions: interest, confusion, surprise, and awe. Interest theories are generated commonly focusing on whether a person's interest includes engagement or integration of self and supplies long term attention and expectancies in educational psychology (Eccles et al., 1983; Krapp, 2003; Krapp, 2005; Renninger & Hidi, 2011; Silvia; 2006, Wigfield et al., 2006). Additionally, the focus of interest research has examined an individual's attention and/or engagement on objects or events with the environment and their sustained interaction (Krapp et al., 1992; Silvia, 2006). Furthermore, Hidi (2011) and Murayama et al., (2019) discussed the idea that interest is associated with reward circuitry, and

the function of interest is perceived as a reward, likewise curiosity (see Section 1.4.2). The approaches of interest are reviewed below.

1.3.1. A Four-Phase Interest Development

A Four-Phase Model of Interest Development is developed by Hidi & Renninger (2006) and (Renninger & Hidi, 2016). The model evaluates interest in the cumulative system that is sequential and distinct, and it is promoted or sustained in situations or subjects showing a progressive development within challenges or opportunities (Renninger & Hidi, 2011). The first phase of the model is situational interest which is triggered by the environment (e.g., recognizing an incongruous subject or information). For example, using attention-grabbing technology and games during class can trigger students' situational interest; yet, their situational interest could be short-lived attention without the sustainable environment support (Linnenbrink-Garcia et al., 2010). The second phase is maintained situational interest that shows attention towards that subject. By following the previous example, if the environmental support continues with classroom activities, including enjoyment and connection to the course material, maintained situational interest can arise. The third phase is emerging individual interest that refers to a psychological state of interest seeking repeated reengagement for particular classes or contents over time. For example, students generate their own curiosity questions by considering their emerging individual interest. The last phase is finalized with well-developed interest. The characterization of this phase is that students have more stored knowledge and more stored value for particular content with positive feelings, for example, a deep-seated interest in science, music, sports, and travel, (Hidi & Renninger, 2006; Rotgans, 2015). With regards to the model, a situational interest measurement is developed (Linnenbrink-Garcia et al., 2010). The situational interest measurement in an academic domain focuses on situational interest as the cumulation of experiences, not an experience in a

momentary time on middle and high school students (Linnenbrink-Garcia et al., 2010). In the same study (Linnenbrink-Garcia et al., 2010), the three factors model (i.e., triggered situational interest, maintained situational interest-feeling, maintained situational interest-value) shows a good fit in educational context.

1.3.2. Interest: the Engagement within Person and Object

Krapp (2007) centres interest within the relation of the person's growing awareness of self and remarks on identifying individuals with interest to improve the feelings and values that support self-intentionality to set consistent goals (Krapp & Prenzel, 2011; Renninger & Hidi, 2011). The Person-Object theory is composed by Krapp (2002). It focuses on the interaction between person and object by including situational interest and individual interest. The theory is similar with the four-phase model of interest development but it uses three stages of development, which are emerging situational interest, stabilized situational interest, and individual interest (Krapp & Prenzel, 2011). Firstly, an emerging situational interest is triggered by external stimuli, and then a stabilized situational interest perseveres during a limited learning phase. In the last phase, an individual interest presents enduring predisposition to have an engagement with a specific object area of interest. Most importantly, Krapp, (2003) discussed the person's awareness of self in the learning process. Even if individuals learn something new, without awareness, learning is probably transpired when individuals perceive something important of self. Krapp (2007) emphasized the importance of psychological needs (e.g., autonomy, competence, and social relatedness) to develop interest in self-regulation.

Likewise, the interest-driven creator theory (IDC) has been recently developed to present suitable learning strategies in the interest loop (creation loop and habit loop of IDC) by Wong et al., (2020). The theory presents the interest loop in three components by considering the first three phases of the four-phase of interest development. The first component is that

triggering interest begins with situational interest of students by touching their curiosity, such as learning a new concept and skill. This stage focuses on design as an activity that increases the initial interest of students for a particular object during learning process. The second one, immersing interest, refers to flow, i.e., the experience of intense emotional involvement and feeling engagement with the designing activity for students' own sake. The activity is intrinsically rewarding feeling during this flow experience. Extending interest refers to meaningfulness and the aim of this stage expands students' interest (enrichment and extension of prior knowledge) for the domain after the immersing process by using the learning activity (Wong et al., 2020). The theory highlights the importance of the connection between subjective feelings and objects during the learning process (Fredrickson, 1998; Silvia, 2008; Thoman et al., 2011).

1.3.3. Interest in task features

The conceptualization of interest has also been examined on task features and environment. Mayer (2008) emphasizes a cognitive theory of multimedia learning that supplies visual and verbal material in an optimal learning condition to distinguish between cognitive and emotional interest. While emotional interest refers to entertaining with text, illustrations, and tools, cognitive interest refers to supportive tools for structural understanding such as coherent text, increased sense of positive affect to support learning (Hidi & Renninger, 2011). Indeed, interest in task features focuses on how individuals could effectively use their engagement, attention, and sustainability with objects for the long term.

The expectancy-value theory underscores interest as a significant component of task value (Eccles et al., 1983; Wigfield et al., 2006). The expectancy-value theory focuses on the conceptualization of individual motivation along with a set of decision theories on work motivation and performance (Ferris, 1977). When children's ability, beliefs and subjective task

values were assessed under the expectancy-value theory of achievement motivation, children's interest diminished in reading and instrumental music over time—but for math and sports, their interest did not change (Wigfield & Eccles, 2000). This result underscores the importance of subjective valuing of children on different activities. Another study shows that while the students' importance ratings of math and English decreased during the transition to junior high school, the ratings declined in math until 7th grade, but English ratings increased (Eccles et al. (1989). The changes of students' interest could depend on the expectancy-values such as exam grades, the complexity of tasks, and the level of their entertainment. Adolescents' valuing for activities could be more positive (Wigfield & Eccles, 2000). The expectancy-value theory underline feelings, values, self-regulation and individual motivation during the process of interest.

1.3.4. The Appraisals of Interest as an Emotion

Interest is considered as an emotion in some theoretical frameworks (Ainley & Ainley, 2011; Ellsworth, 2003; Silvia, 2006). Silvia (2008) defined the psychology of interest that is enjoying a renaissance by showing examples of many emerging areas, such as interest and arts, interest and education, interest and vocations, and interest and personalities. To understand the link between interest and objects, cognitive and affective appraisals are examined commonly in interest as emotion research (Ainley, 2007; Hidi & Renninger, 2006; Thoman et al., 2011). Appraisal theories of emotions allow us to understand the starting points and consequences of interest (Silvia, 2008). Silvia deals with the source of emotional response during the person's engagement with the task by including cognitive appraisals. He defines separately *interest* (i.e., it refers to basic emotion such as happiness, fear, anger) and *interests* (i.e., it refers to self-sustaining motives which supports engagement with objects) to develop the appraisals of interest (Silvia, 2008). Along with this, he emphasized the idiosyncratic approach in *interests*

when people engage with tasks for their own sake (Renninger & Hidi, 2011). For example, his study about the emotion of interest and the emotion of enjoyment on a set of paintings (disturbing and relaxing paintings) showed that interest and happiness/pleasantness were different appraisals (Turner & Silvia, 2006). They interpreted that the disturbing paintings might be highly interesting, but not pleasant; the relaxing paintings might offer a high pleasantness but were not interesting in the experiment.

Moreover, Silvia (2008) discusses that interest is produced by collative variables (e.g., novelty, unfamiliarity, and complexity, Berylne, 1960). Most importantly, his study about this view focuses on two appraisal components, which are an appraisal of novelty-complexity and an appraisal coping potential (Silvia, 2005). The novelty-complexity appraisal refers to the centre of familiar appraisals involving new, unexpected, and complex events, and the coping potential refers to the ability to understand an object, which is identified poorly by the first appraisal. Along with four experiments, which used: complex polygons, abstract poetry, and simple/complex pictures, the study elicits the appraisals of interest with these components. While coping potential appraisals are associated with complex polygons, abstract poetry was found to be more interesting. Furthermore, Ainley (2007) focuses on interest and emotional responses during an individual's interaction with a task by considering cognitive appraisals. For instance, the PISA international study suggest that students' enjoyment of science is a powerful predictor of value for scientific achievement (Ainley & Ainley, 2011). In this study, entertainment during science learning provides an understanding of the importance of the affective appraisal of interest. Indeed, interest as an emotion, is different from other basic emotions. Collative variables as well as cognitive and affective appraisals promote the understanding of the emotion of interest during engagement with objects.

1.4.Remaining issues in distinction between curiosity and interest

As briefly introduced in the previous sections, curiosity and interest theories especially highlight knowledge acquisition and information-seeking processes. In this section, the remaining distinctions of curiosity and interest will be discussed.

1.4.1. Characterization of Knowledge Gap

Curiosity and interest may be distinguished by the characteristic of knowledge gap during information-seeking behaviour. Curiosity might only be triggered to find a knowledge gap when the individual perceives that s/he knows less about a topic from his/her prior knowledge (Loewenstein, 1994). The trigger for a knowledge gap is considered personally relevant, practical, and important in the value of resolving curiosity on the experience of an individual (Shin & Kim, 2019). As for interest, the intensity of attention, feeling engagement, and the integration of self are highlighted when seeking an information gap, and also the individual having reasonable knowledge about the topic is assumed. (See the example about learning about the solar system in class, Shin & Kim, 2019). For example, curiosity and situational interest could be understood by considering the perspective of their knowledge gap. Situational interest pursues hedonic experiences to be a pleasure and avoids pain or danger in-the-moment experience, whereas curiosity follows uncertainty and risk-taking behaviour, and sometimes is not a matter of positive or negative result to find out a knowledge gap (Berridge, 2012; Grossnickle, 2014; Shin & Kim, 2019; Loewenstein, 1994). The difference of attention can be seen in anticipation, expectancy, and affect, between curiosity and situational interest when exploring an information gap. This is because if the individual is curious, the power of surprise, novelty and the coping with the unknown are substantial. However, for situational

interest, it may not be as large as curiosity (Ainley, 2019 Alexander, 2019; Grossnickle, 2014; Hidi, 2006; Shin & Kim, 2019). Commonly, when an individual is interested, the aim of the individual is not to fill the knowledge gap itself, but is motivated for the long term (e.g., vocational interest) to pursue or integrate cumulatively with previous knowledge and self (Krapp, 2002; Renninger & Hidi, 2011; Renninger & Hidi, 2019; Wong et al., 2020). As such, despite the similarity of curiosity and interest regarding the knowledge gap, they might be distinguished in terms of the characterization of knowledge gap (Fastrich et al., 2017; Murayama et al., 2019; Silvia et al., 2008).

1.4.2. Incentive Salience and Knowledge Acquisition as Rewarding Feeling

How can knowledge acquisition as a rewarding feeling be different for curiosity and interest? Interest is defined as the extension of knowledge in more detail and commonly for long-term application and integration of self. However, curiosity is connected to the decrease of uncertainty in a short time temporally, or as a general motivating function because of the intensity of curiosity for unknown pieces of information (Fastrich et al., 2017; Grossnickle, 2014; Hidi & Renninger, 2011; Krapp, 2007; Loewenstein, 1994; Murayama et al., 2019; Silvia, 2006; Wade & Kidd, 2019). The duration of knowledge acquisition (i.e., immediately or in the long-term), the level of information (i.e., essential information or deep knowledge), and the use of knowledge (i.e., career, personal development, trivia type of information) have all been discussed as the distinctions of curiosity and interest in the literature. Along with these discrepancies, the rewarding feeling of knowledge acquisition might be different for curiosity and interest. From this perspective, Murayama et al. (2019) present the reward learning model to understand curiosity and interest during the knowledge acquisition process. For example, in the model, the expected reward value of information is evaluated as a function of reward prediction errors by comparing the difference between the expected reward value and the actual

reward value of new information (Murayama et al., 2019). This difference shows how much individuals are surprised with the new information, and this surprise signal is defined as an "information prediction error", which means also the reward value or the expected reward values of new information (Hidi & Renninger, 2019; Marvin & Shohamy, 2016; Murayama et al., 2019).

These distinctions present a notion about how one can feel curiosity and interest differently when learning something in terms of the characterisation of the knowledge gap, as well as the rewarding feeling of knowledge acquisition. However, the problem with these approaches is they still conceptualise curiosity and interest separately (or only define one of the concepts), focusing little on the commonalities between them. As curiosity and interest are operatives together during the learning process, simply distinguishing them may not be enough to use them effectively in education. How can we turn them into an integrative framework together to account for both their similarities and differences? Murayama (2019) developed a reward-learning framework for this issue, which is defined in more detail below.

1.5. Reward Learning Framework

I have reviewed the literature on curiosity, interest, and their measurements, highlighting the different conceptualizations and theoretical perspectives to understand them. How can we understand them from an integrative perspective? This is a challenging task, but some recent work has attempted to put them in a common framework. This is called a reward-learning framework of knowledge acquisition (Murayama, 2019).

Reward learning (or reinforcement learning) supports the psychological need for learning behaviours by using reward signals in the adaptive learning system and artificial intelligence (Li et al., 2020). Reward-learning has been a fundamental theoretical framework in recent curiosity research. For example, curiosity has been studied to develop a curiosity-

driven strategy in personalised learning systems under reinforcement-learning algorithms (Han et al., 2020). Information-seeking phenomena with knowledge-gap theory (Loewenstein, 1994) and the U-shaped curve (Kang et al., 2009) have supported knowledge acquisition as a rewarding feeling. Interest is considered a critical motivational variable that focuses on a person's growing awareness of self, and engaging this self in their activity (Hidi et al., 2019; Krapp, 2007). Critically, interest has also been argued in terms of extrinsic and intrinsic reward (Murayama et al., 2019), suggesting its relevance to reward-learning processes. Both curiosity and interest emphasise the autonomy of individuals when people discover or learn from their experiences. After all, the importance of rewards during the process of curiosity and interest has seen increased attention in the existing literature (FitzGibbon et al., 2020; Niehoff & Oosterwijk, 2020; Noordewier & van Dijk, 2020; van Lieshout et al., 2021).

Murayama et al. (2019) proposed a reward-learning framework that explains how people maintain and engage in information-seeking behaviour during the knowledge-acquisition process. The framework supposes that knowledge acquisition induces rewarding feelings, and expected reward value is a regulatory point by which information-seeking behaviour is initiated. Also, expectancy beliefs, personality traits and collative variables (e.g., novelty, complexity, challenge and surprise) are considered as moderators between the awareness of knowledge gaps and information-seeking behaviour. Critically, this reward-learning process is a self-sustained process that supports long-term engagement in the knowledge-acquisition process.

Figure 1 summarises Murayama et al.'s (2019) framework. When people become aware of a knowledge gap, they become motivated to seek information. The actual initiation of information-seeking behaviour is controlled by moderator variables noted above. If they successfully acquire the knowledge, this new knowledge would be integrated into their previous knowledge. Knowledge acquisition is perceived as a rewarding experience and

increases the expected reward value of new information. The rewarding feeling and the expected reward value of new knowledge are compared to the decision to replete a knowledge base; expanded knowledge gaps lead to further knowledge gaps, which promotes further information-seeking behaviour.

As noted by Murayama et al. (2019), the framework is based on reward-learning models in the literature of reinforcement learning, and is consistent with the knowledge-gap theory of curiosity (Loewenstein, 1994), the four-phase model of interest development (Hidi & Renninger, 2016) and the expectancy-value approach to interest (Wigfield & Cambria, 2010). Notably, the framework does not include interest and curiosity as an element, but these constructs are defined as being construed through the process of knowledge acquisition.

Previous studies commonly focused on superficial differences (e.g., epistemic/perceptual curiosity, state/trait curiosity, interest/deprivation-type curiosity, social curiosity, situational/individual interest), yet less attention was paid to the psychological mechanism of curiosity and interest. Likewise, although curiosity and interest scales highlight information-seeking behaviour, there is no scale concerned with their mechanism either together or separately. Conversely, the reward-learning model explicitly discusses the psychological mechanism of curiosity and interest together along with reward learning. The model does not aim to distinguish curiosity and interest; on the contrary, it focuses on understanding curiosity and interest as rewarding feelings during knowledge acquisition.

The reward-learning framework provides a new perspective: seeing the existing distinction between different types of curiosity and interest. For instance, interest- and deprivation-types of curiosity (I-type and D-type) emphasised the wanting and liking component of knowledge acquisition. The wanting component of curiosity can be seen as an incentive salient aspect of expected reward value in reward learning (Berridge, 2007). On the other hand, I-type curiosity can be seen as focusing on the actual positive rewarding feelings

(not an expected value of feelings) after acquiring the knowledge. Literature on interest has supported the idea that interest is a rewarding feeling (see Section 1.2.2). Importantly, I-type curiosity presents a limited perspective to understand interest through common definitions, such as a person's growing awareness of the self and a long-term engagement with a task or an activity. On the other hand, the reward-learning model enables researchers to understand curiosity and interest by focusing on the developmental aspect of interest, which has been overlooked in previous curiosity-based studies. Reward-learning emphasises the commonality of curiosity and interest in terms of a rewarding feeling; although the remaining distinctions of curiosity and interest have continued (see Section 1.4), their similarities may strengthen an understanding of the concepts better than if it is maintained that they are simply distinct. From this perspective, curiosity and interest may motivate people in a complementary manner within the learning system.

Importantly, the theoretical framework can make two remarks with regard to the difference and similarity of curiosity and interest. First, the framework indicates that curiosity and interest are distinguished not at the level of psychological process, but at the level of subjective experiences. Therefore, it is important to analyse what people think and construe the constructs of curiosity and interest. Second, although people may make a distinction between curiosity and interest, they are both on the common reward-learning process, and therefore we should examine the issue by focusing on the rewarding feeling that people acquire during the knowledge acquisition processes.

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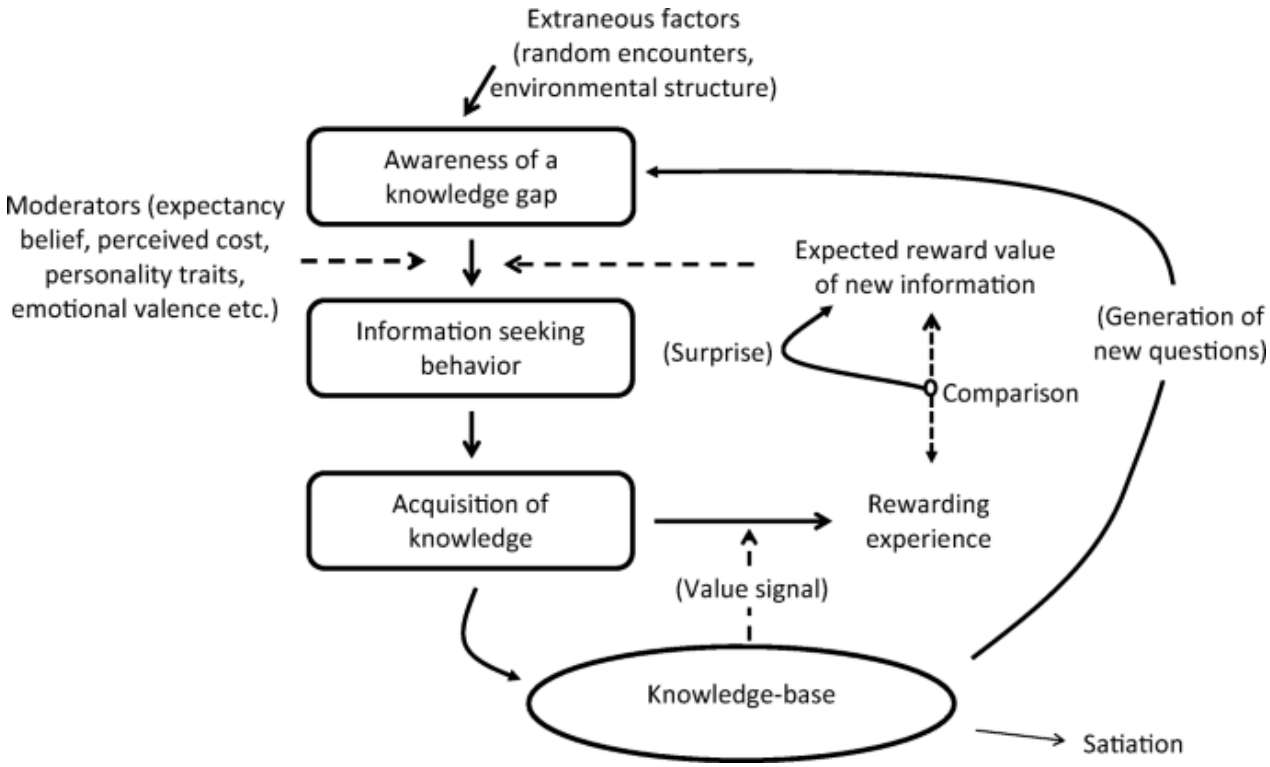

Figure 1. 1. The Reward Learning Framework

1.6. The measurements of Curiosity and Interest

The lack of consensus poses a challenge to empirical investigations of curiosity and interest, which need to "measure" these constructs somehow. For example, curiosity and interest are often examined together by self-reported measures. One such instance is the Interest-Deprivation Type Epistemic Curiosity scale, which distinguishes interest-type vs deprivation-type of curiosity (Litman 2005). As the name indicates, in this scale, interest is treated as one component of trait curiosity. Likewise, Litman and Spielberger (2003) showed that interest emerges in measures of curiosity (i.e., noted by Berlyne in his definitions of epistemic curiosity, defined as a "drive to know" in the presence of a knowledge gap, and perceptual curiosity, defined as "the curiosity which leads perception of stimuli" via the tactile stimulation of humans and animals) such that curiosity is similar to triggered interest. However, it is argued that interest has a broader range of triggering variables not limited to collative ones (Grossnickle, 2014; Renninger & Hidi, 2016). Interest is also often assessed by a subscale of intrinsic motivation (e.g., Chen and Ennis, 2004), but the boundary between intrinsic motivation and interest is also unclear. Despite numerous self-report measures (e.g., State-Trait Personality Inventory [Spielberger, 1979]; Curiosity/interest in the World [Peterson and Seligman, 2004]; Academic Curiosity Scale [Vidler and Rawan, 1974]) and Epistemic Curiosity Scale; Litman 2008) as well as task-based assessments/manipulations (e.g., trivia questions), there are no agreed-upon measures of curiosity and interest: they are generally based on subjective judgements or interpretations of researchers (Alexander 2019). The issue is not limited to self-reported measures. Even studies that use physiological or neuroscientific methods (e.g., eye-tracking, functional magnetic resonance imaging [Brod & Breitwieser, 2019; Lau et al., 2020]) have no agreed-upon indicators of curiosity and interest.

1.6.1. Measurements of Curiosity

Several attempts have been made to measure curiosity in terms of knowledge, sensation seeking and multidimensional trait forms, and the scales examined in this section utilise such factors in various ways. The following review will present features of curiosity measurements, such as the dimensions of the scales, their construct validities and their correlations; supporting information will be presented in the table after their reviews.

1.6.1.1. Epistemic Curiosity scale with Diversive (EC/D) and Specific (EC/S) components. Developed by Litman and Spielberger (2003), a key aspect of this curiosity measurement is its focus on *epistemic* curiosity. As proposed by Berlyne (1954), epistemic curiosity is measured via two dimensions: *diversive* curiosity refers to seeking stimulation regardless of the specific content or source, whilst *specific* curiosity refers to a motivation to investigate a novel stimulus to know (see more information of the scales in Table 1.1). The construct validity of the EC/D and EC/S scales has been demonstrated by its relation to other curiosity scales and trait forms, such as anxiety, anger and depression (Wagstaff et al., 2020). Furthermore, the EC scales are used as a factor under the growth/development of skills to investigate the possible co-existence of global and specific motivational factors, to predict the career paths of doctoral students; i.e., will they become professors or managers (Burk & Wiese, 2018). Burk and Wiese postulated that the desire of becoming a professor is negatively associated with the growth/development of skills (EC), but that it is positively associated with reputation and competition. Concerning the desire for a managerial career, this is positively associated with difficult tasks that assist towards growth/development of skills. EC of growth/development skills might emphasise their desire to adequately learn for a career as a professor or manager.

1.6.1.2. Curiosity as a Feeling of Deprivation (CFD) scale and Epistemic Curiosity Interest and Deprivation (EC-I/D) scales. Another Epistemic Curiosity (EC) scale (Litman & Jimerson, 2004) is the Curiosity as a Feeling of Deprivation (CFD) scale. Whilst curiosity is described as unpleasant feelings by early accounts of exploratory behaviour theorists, it is defined as a pleasurable emotion by contemporary theorists (e.g., Litman & Jimerson, 2004) (see Section 1.2.3). According to Litman and Jimerson, CFD presents feelings of uncertainty and tension, which supports information-seeking and problem-solving behaviour. The scale is presented with three subdimensions: intolerance, competence and problem-solving (15 items in total). The scale shows factorial validity with CFA, convergent validity in terms of the relations with other curiosity scales and discriminant validity concerning the relationship with other measurements of curiosity (i.e., feelings of deprivation and interest) (Litman & Jimerson, 2004). Whilst the EC scale (Litman & Spielberger, 2003) shows a significant difference between gender (males are higher than women on the EC scale and EC-S subscale), there is no significant gender difference seen in the CFD scale (Litman & Jimerson, 2004).

The EC-I and EC-D scales were developed by Litman (2008) to present 10 items across two dimensions—interest and deprivation—and show a good fit with confirmatory factor analysis. The scales also provide convergent validity since they have been positively related to the Typical Intellectual Engagement (TIE) scale (Reading, Contemplate, Curious) and the Need for Cognition (NfC) (using the Big-Five personality traits of Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism etc) within a series of studies that incorporated German, English and Chinese samples. Also, EC scales demonstrated discriminant validity with the other scales (e.g., Vulnerability, Impulsiveness, Trust) (see Litman, 2008).

1.6.1.3. Novelty-Seeking scale (NSS). Several researchers have sought to develop a measurement of curiosity in terms of sensation seeking (e.g., Novelty Experiencing scale

[Pearson, 1970]; Sensation-Seeking scale-V [Zuckerman, 1979]; Impulsive Sensation-Seeking scale [Zuckerman et al., 1994]).

The Novelty-Seeking scale (NSS) (Cloninger et al. 1993) measures novelty-seeking tendencies; it is a subdimension of the Temperament and Character Inventory-Revised (TCI-R). Cloninger, Svrakic and Przybeck (1993) proposed four derived facets that define novelty-seeking factors: exploratory excitability, impulsivity, extravagance and disorderliness. The NSS presents convergent validity (e.g., Extraversion and Openness) and divergent validity (e.g., Agreeableness and Conscientiousness) (Zuckerman & Aluja, 2015). As can be seen in the items in Table 1.2, they include the core characteristics of curiosity, such as trying new things, actively thinking and taking risks (Ainley, 2019; Grossnickle, 2014; Loewenstein, 1994).

1.6.1.4. Sensation-Seeking scale (SSS-V) and Perceptual Curiosity scale (PCS). The Sensation-Seeking scale-V (SSS-V) (Zuckerman, 1994) measures Thrill and Adventure Seeking, Experience Seeking, Disinhibition and Boredom Susceptibility. The scale displays convergent (e.g., Extraversion and Openness to Experience) and divergent (e.g., Agreeableness and Boredom Susceptibility) validity and consists of 40 items of forced-choice.

The Perceptual Curiosity scale (PCS) (Collins et al., 2004) measures individual differences by evaluating specific and diversive curiosity (see Table 1.2 for more information about the items). The study examined the PCS's comparisons to EC and sensation seeking. The results show positive correlations with the EC and sensation-seeking measures, demonstrating convergent validity. To demonstrate divergent validity, there is no statistically significant correlation with trait anxiety, anger or depression measures. PCS focuses more on sensory reactions than cognitive stimulation (Collins et al., 2004).

1.6.1.5. Curiosity and Exploration Inventory-I and Curiosity and Exploration Inventory-II. Investigating trait forms of curiosity is a continuing concern within

measurements. The Curiosity and Exploration Inventory-I measures state and trait curiosity by focusing on exploration (i.e., appetite motivation for novelty and challenges) and absorption (i.e., engaging with specific activities) (Kashdan et al., 2004). The items have been developed globally, avoiding the domain specificity of curiosity to increase the generalisability of the measurement (see Table 1.3). In addition, the scale presents factorial validity with the CFA and the EFA across two factors. The examination of convergent and discriminant validity of their measure reveals that both Exploration and Absorption show strong positive correlations with curiosity measures and Openness to Experience. Discriminant validity was demonstrated with the behavioural inhibition system, extrinsic motivation and the domains of Conscientiousness and Agreeableness (Cavojova & Sollar, 2007).

Conversely, the Curiosity and Exploration Inventory-II (Kashdan et al., 2004) focuses on expanding the breadth of the construct with exploration or stretching (i.e., actively seeking information or experiences) and embrace (i.e., the readiness to embrace novelty, uncertainty and unpredictability in the flow of life). However, the scale tends to evaluate trait curiosity along with two items—daily stretching (e.g., "Today, I viewed challenging situations as an opportunity to grow and learn") and embracing (e.g., "Everywhere I went today, I was out looking for new things or experiences")—to present state curiosity (Wagstaff et al., 2020). As for the scale's validity, the CFA has shown to be a good fit with the two-factor model for construct validity, and Item Response Theory has supported discrimination between the items. Openness to Experience and Personal Growth have demonstrated the strongest correlations with curiosity (Kashdan et al., 2009; Wagstaff et al., 2020). With other measures involving happiness, psychological well-being, social well-being, depression, anxiety and stress, the Curiosity and Exploration Inventory-II shows evidence of discriminant validity (Kashdan et al., 2009).

1.6.1.6. Social Curiosity scale. Another measurement of curiosity has been developed with a focus on social curiosity. The Social Curiosity Scale (SCS) (Renner, 2006) was developed to assess social curiosity, which reflects people's interest in other people's thoughts, feelings and behaviour. Renner argued that the measurement focuses on curiosity regarding the social world instead of the realm of perceptual experience (e.g., see the Epistemic Curiosity Inventory, Perceptual Curiosity scale and Melbourne Curiosity Inventory). SCS measures using two factors: first, *general social curiosity* (five items) refers to a broad interest in knowledge acquisition regarding other people's behaviours, actions, and feelings; second, *covert social curiosity* (also five items) refers to expressing interest in the primary obscure or covered information of interpersonal relationships (see Table 1.3). The result of the CFA shows the scale to be a good fit, and the EFA supports the loadings of the two factors. Convergent validity has been demonstrated as having a moderately high correlation with other measures of curiosity (e.g., Epistemic Curiosity Inventory, Curiosity and Exploration Inventory: Trait Form, and Melbourne Curiosity Inventory: Trait Form). Also, discriminant validity has been demonstrated using the relationships with other personality traits (e.g., Neuroticism and Agreeableness).

1.6.1.7. Interpersonal Curiosity scale (IPC). Litman and Pezzo (2007) developed the Interpersonal Curiosity scale (IPC) by focusing on social curiosity, defined as the desire to know about people's information. Although the scale consists of 15 items, it is grouped into three subdimensions: curious about emotions, spying and prying, and snooping (see Table 1.3). The CFA is used to demonstrate factorial validity, and Litman and Pezzo also examined correlations with other curiosity measures (e.g., Interpersonal Curiosity scale [Singer & Antrobus, 1963]; Epistemic Curiosity scale [Litman & Spielberger, 2003]; Measurement of Curiosity as a Feeling of Deprivation [Litman & Jimerson, 2004]) and personality measures (Attitudes Towards Gossip Scale [Litman & Pezzo, 2005]; Tendency to Gossip Questionnaire

[Nevo et al., 1994]). The Tendency to Gossip Questionnaire (TGQ) has demonstrated strong positive correlations with the scale, which also found significantly a positive correlation (r=0.36) with attitudes and self-evaluation of transmittal in gossip (Renner, 2006). While TGQ support divergent validity with IPC, this finding suggests people, who are interpersonally curious, aim to reduce uncertainty information about another people. This might motive people to learn intellectual knowledge and share people-information with others.

1.6.1.8. Melbourne Curiosity Inventory. Melbourne Curiosity Inventory was developed by Naylor (2007). Over the relationship between anxiety and curiosity, the state-trait formulation of the anxiety theory was similarly developed for curiosity studies. Whilst trait curiosity focuses on stable individual differences in curiosity experiences, state curiosity defines the momentary experiences of an individual's specific situation. The test–retest correlations of the trait subscale were higher than the correlation of repeated testing for the state subscale, indicating the validity of the scale. Additionally, Holland's (1985) six-fold RIASEC classification of occupational interests—Realistic, Investigative Artistic, Social, Enterprising and Conventional—were correlated with the scale and the results supported its construct validity. The investigating interest showed the highest correlation with both of the subscales.

1.6.1.9. Five-Dimensional Curiosity scale and a revised Five-Dimensional Curiosity scale. Kashdan et al. (2018) built a 25-item trait Curiosity scale to develop a multidimensional trait curiosity measure, which consists of five dimensions (see example items in Table 1.3): *joyous exploration* refers to the enjoyment of novel stimuli; *deprivation sensitivity* defines a lack of access to specific information; *stress tolerance* refers to a feeling to manage an unfamiliar stimulus; *thrill-seeking* refers to passionately looking for an adventure; and *social curiosity* refers to being curious about other people's lives. The scale aims to generate a comprehensive curiosity measure and the core dimensions of curiosity (epistemic curiosity,

sensation seeking, thrill-seeking) by evaluating curiosity in a matchless appraisal structure since people interpret a situation as new, unexpected, complex, surprising, novelty and vague.

This appraisal structure of trait curiosity focuses on the novelty challenge and the capacity of managing stress in a situation, with an object or with a person. When a cluster analysis of subscale responses is used, the results show statistical differences for demographics, personality, attitudes, values, passionate interests, expertise, social media usage, magazine preferences and websites when evaluating the appraisal structure of trait curiosity. Whilst showing the CFA evidence for factorial validity, the Big-Five personality traits support the construct specificity of the scale. Additionally, partial correlations present the unique contribution of each dimension towards the personality traits. It is also worth noting that the research has collected the data from a wide variety of populations, using samples from various age groups.

Furthermore, the scale is revised and appended to include *overt social curiosity* and *covert social curiosity* by separating the dimension of social curiosity (Kashdan et al., 2020). Overt social curiosity refers to a desire to learn from other people, whilst covert social curiosity refers to a surreptitious interest in what other people do or say. Overt social curiosity shows positive correlations with general IPC, Open-mindedness, Extraversion and Agreeableness, but it presents a low correlation with loneliness, social anxiety and negative emotionality. Covert social curiosity has shown significant positive correlations with snooping, prying and surreptitious social behaviour. These correlations could indicate the validity to distinguish both overt and covert social curiosity.

1.6.1.10. M-Workplace Curiosity scale. The M-Workplace Curiosity scale was developed as a multidimensional workplace trait curiosity scale in both English and German (Kashdan et al., 2020). The scale focuses on a comprehensive hierarchical structure of curiosity in the workplace using four *factors: joyous exploration, deprivation sensitivity, stress tolerance*

and openness to people's ideas. A cross-cultural comparison showed similar results for the psychometric properties and effect sizes between the American and German participants (Wagstaff et al., 2020). The construct validity was examined by looking at the correlations with job satisfaction, work engagement, innovation behaviours, healthy work relationships and work-related outcomes. The scale was further validated by various statistical methods such as a hierarchical regression, test–retest correlation and the CFA.

1.6.1.11. Self-Curiosity Attitude–Interest scale (SCAI). The Self-Curiosity Attitude–Interest scale (SCAI) has been developed and validated using three independent samples (Aschieri et al., 2015). SCAI features two dimensions: *attitude towards self-curiosity* is defined as "cognitive propensity towards exploring one's inner world" (Aschieri et al., 2015, p. 326, and *interest in increasing knowledge of the self* is defined as an "emotional/motivational pull to understand oneself better" (p. 326). The scale is generated for its use in clinical practice and research. With seven items, the measurement demonstrates good internal consistency, test–retest reliability and construct validity as assessed by the relationship with other relevant constructs (e.g., the Curiosity and Exploration Inventory-II, Big-Five Inventory and Rumination and Reflection Questionnaire were applied).

Table 1.1. The measurements of curiosity

	Trait/ State	Number of Items	Sample	Factor	Language	Item
1. Epistemic Curiosity Scale-(ECI and D-type of curiosity) (Litman, 2008)	Trait	10	Collage students	Interest, Deprivation	English, Chinese, German	I find it fascinating to learn new information/ **Interest** I work like a fiend at problems that I feel must be solved/ **Deprivation**
2. Epistemic Curiosity Scale- Curiosity as a Feeling of Deprivation Scale (Litman and Jimerson 2004)	Trait	15	Collage students Non-student samples	Intolerance, competence, problem-solving	English	Conceptual problems keep me- awake thinking about solutions/ **Problem-solving** Important to feel knowledgeable/**Competence** Critical of ideas and theories/**Intolerance**
3. Epistemic Curiosity (Specific and Diversive components) (Litman & Spielberger, 2003)	Trait	10	Collage students	Diversive, Specific	English, German	Enjoy exploring new ideas/ **Diversive** New kind of arithmetic problem/enjoy imagining solutions/ **Specific**

	Number of Items	Sample	Factors	Language	Item
4. Perceptual Curiosity Scale (Collins et al., 2004)	16	Undergraduate students	Diversive, Specific	English	Discover new place to go/ **Diversive** Hear something/ see what it is/ **Specific**
5. Novelty Seeking Scale (Cloninger et al. 1999)	60	Undergraduate students	Exploratory excitability, Impulsiveness, Extravagance and Disorderliness	English	I often try new things for fun or thrills even if most people feel it is a waste of time/ **Exploratory Excitability** I often do things based on how I feel at the moment without thinking about how they were done in the past/**Impulsiveness** I am more reserved and controlled than most people/ **Extravagance** I like it when people can do whatever they want without strict rules and regulations/**Disorderliness**
6. Sensation-Seeking Scale V (Zuckerman, 1979)	40	Undergraduate students	Thrill and adventure seeking, experience seeking, disinhibition, and boredom susceptibility	English	A. I like 'wild' uninhibited parties. B. I prefer quiet parties with good conversation.

	Items No	Sample	Factor	Language	Item
7. Five-dimensional curiosity scale (Kashdan & Disabato et al., 2018)	25	Two community samples and one MTurk sample	Joyous exploration, deprivation sensitivity thrill seeking, social curiosity, stress tolerance, (reversed score)	English, Hebrew	I find it fascinating to learn new information/**Joy exploration** I can spend hours on a single problem because I just can't rest without knowing the answer/**Deprivation sensitivity** I cannot handle the stress that comes from entering uncertain situations/**Stress tolerance** I like finding out why people behave the way they do/**Social curiosity** Risk-taking is exciting to me/**Thrill seeking**
8. Five-dimensional curiosity scale (Kashdan et al., 2020)	24	One working adult sample and one community adult sample	Joyous exploration, deprivation sensitivity, stress tolerance, thrill seeking, covert and, overt social curiosity	English	When people quarrel, I like to know what's going on. / **Covert social curiosity** When talking to someone who is excited, I am curious to find out why. /**Overt social curiosity**
9. Melbourne Curiosity Inventory (Naylor, 2007)	20	Undergraduate students	State, trait	English	New situations capture my attention/ **State** I enjoy exploring new place/ **Trait**
10. Curiosity and exploration inventory (Kashdan et al., 2004)	7 (state) 4 (trait)	Four college samples, one internet-based survey	Exploration, absorption	English, German	When I am actively interested in something, it takes a great deal to interrupt me. / **Absorption** Everywhere I go, I am out looking for new things or experiences. /**Exploration**

	Item No	Sample	Factor	Language	Item
11. Curiosity and exploration inventory II (Kashdan et al., 2004)	10	Three college samples	Stretching, embracing	English	I prefer jobs that are excitingly unpredictable. / **Embracing** I am at my best when doing something that is complex or challenging. /**Stretching**
12. M-Workplace curiosity scale (Kashdan et al., 2020)	16	Four samples with United States and German working adults	Openness to people's ideas, stress tolerance, deprivation sensitivity, joyous, exploration	English, German	It is important to listen to ideas from people who think differently. / **Openness to people's ideas** At work, I seek out opportunities to expand my knowledge or skills/ **Joyous exploration** When given a complex problem at work, I can't rest until I find the answer. / **Deprivation sensitivity** When work is anxiety provoking, I tend to explore rather than avoid. /**Stress tolerance**
13. Interpersonal Curiosity Scale (Litman & Pezzo, 2007)	15	Two college student sample	Curious about emotions, spying and prying, snooping	English	Try to understand people's feeling. **/Curious about emotions,** Feel comfortable asking about private life. / **Spying and prying** Look at things in people's room/**Snooping**
14. Social Curiosity Scale (Renner, 2006)	10	College students and community participants	General social curiosity, covert social curiosity	English	When I meet a new person, I am interested in learning more about him/her./ **General social curiosity** When on the train, I like listening to other people's conversations./ **Covert social curiosity**
15. Self-Curiosity Attitude-Interest Scale (Aschieri et al., 2020)	7	Psychology blogs, Commercial	Attitude toward Self-curiosity, Interest in	Italian, Spanish	The best part of travelling is what it teaches us about ourselves. /**Attitude toward Self-curiosity**

	mailing lists, and social networks.	increasing knowledge of self	I get bored when I have to talk about my feelings./**Interest in increasing knowledge of self**

1.6.1.a. Evaluation of curiosity measurements

Collectively, these scales outline a critical role for measuring curiosity based on the theories. The measurements are reviewed by considering knowledge or experience, sensation seeking and multidimensional trait forms of curiosity. The diversity of the samples' nationalities could contribute to generalising the perspective of the curiosity measurements. However, no new scales involving young children have appeared for over three decades (e.g., Children's Scientific Curiosity [Harty & Beall, 1984]; Teacher-classification, "What would you do" task [Maw & Maw, 1970]). The measurements are generated from a four-to-seven-point Likert scale, whilst previous scales are dichotomous (e.g., True/False for the Academic Curiosity scale [Vidler & Rawan 1974]; Ontario Test of Intrinsic Motivation [Evans, 1971]). This change has allowed more freedom for respondents to express their feelings in the current research (Comrey, 1988).

When focusing on knowledge or experience as a common feature of curiosity, epistemic curiosity, specific curiosity and diversive curiosity developed by Berlyne (1954) are evaluated using EC scales. These scales showed convergent and discriminant validities of EC. Curiosity as a Feeling of Interest and Deprivation is distinguished within EC, and Litman and Spielberger (2003) include an interest statement (e.g., "I am interested in discovering how things work") in their EC scale. Although conceptualizing interest as part of curiosity might decrease the construct validity of curiosity measures as separated from interest, it supports the idea of measuring curiosity and interest together.

Another focus is sensation seeking in the theories and the measurements of curiosity. The sensation-seeking scales emphasise the importance of sensory stimulation in curiosity. Although these measurements support understanding the emotionality behind the exploratory behaviours of curiosity, they could be differently considered during the reward learning process

(Murayama et al., 2019). Moreover, curiosity as trait forms has been approached specifically in the multidimensional curiosity measurements. Whilst the scales contribute to understanding the construct of curiosity, they can also be used for improving organisational practices by focusing on knowledge acquisition for human resource development (Wagstaff et al., 2020).

1.6.2. Measurements of Interest

Interest measurements have commonly been evaluated in academic settings. Measurements often follow the Four-Phase Model of Interest Development (Hidi & Renninger, 2006), Educational Psychological Conceptualisation of Interest (Krapp, 2007) and vocational interest (Gati 1991; Holland 1985). Linnenbrink-Garcia et al. (2010) developed a Situational Interest scale (SIS) to measure individual interest by examining repeated interactions in the classroom context as a classroom-based situational interest (see Section 1.3.1). Therefore, the modification of this scale could be made by focusing on all classes generally instead of on a specific lesson; this would help to understand a generalised situational interest during the learning process. Additionally, Hidi and Reninger (2006) argued that if domain knowledge is high, situational interest is less; conversely, if the knowledge is low, the more situational interest could be observed. SIS supported the distinction within situational interest, by confirming the three factor structure of it: triggered-situational interest, maintained- situational interest-feeling, and maintained-situational interest-value. Whilst the SIS presents the item "My maths teacher is exciting" as a triggered-situational interest (SI), the items "I like what we are learning in maths this year" and "What we are learning in maths this year can be applied to real-life" are defined with maintained-situational interest as a feeling and maintained-situational interest as a value respectively. Together with the CFA, a high correlation between triggered-situational interest and maintained-situational interest-feeling is observed among the younger participants. However, older participants show a particularly high correlation between

maintained-situational interest-feeling and maintained-situational interest-value (Linnenbrink-Garcia et al., 2010); this result might be a reflection of the developmental change between younger and older learners, which is supported by theoretical suggestions (Wigfield & Eccles, 1992).

Similarly, the Individual Interest scale (IIS) was developed by Rotgans (2015). The study evaluates the construct of individual interest, cognitive engagement, curiosity, enjoyment, self-efficacy, attention and boredom in a specific domain. These constructs showed a high positive correlation with the IIS, aside from boredom. Moreover, the scale can predict students' cognitive engagement (standardised $\beta = .69$) and "on-task behaviours and attitudes", with the CFAs of the three classes (i.e., history, chemistry, and geography) demonstrating a good fit.

Whilst the items of the SIS focus on general feelings (e.g., "I like maths"), the IIS emphasises the intensity of individual interest (e.g., "When I am reading something about biochemistry or watching something about biochemistry on TV, I am fully focused and forget everything around me"). Whilst both measurements support measuring situational and individual interests, thus revealing their discriminant validity, modifying the items on different educational contexts could generate a general construct of situational and individual interest in education.

Other interest scales are the Academic Interest Scale for Adolescents (AISA) (Luo et al., 2019) and the Global Academic Interest Scale for Undergraduate and Graduate Students (GAIS) (Lee & Durksen, 2021). The AISA measures four dimensions—emotion, value, knowledge and engagement—whilst the GAIS focuses on a passion for learning, confidence in the future, career aspiration and self-expression. The AISA has been applied to different specific domains, and the samples of the GAIS include diverse university programmes and study majors (e.g., bachelor, master, PhD, engineering, economics, science). The GAIS

examines life and goals, cognition, emotions, personality and value to provide a construct validity of dimensions concerning the measurement of undergraduate students. As for the AISA, the relationship between the construct of intrinsic motivation and adolescents' flow state learning is examined by focusing on maths, English and Chinese classes. The scale showed a good fit with CFA. In addition, internal consistency and test-criterion relationships further support the construct validity.

The focus-of-interest measurements are mostly concerned with their educational applications. Also, the Four-phase Model of Interest Development and Vocational Interest (e.g., Global Academic Interest scale, see Table 1.4) are particularly highlighted as foundational theories for interest measurements. Whilst interest is considered as part of intrinsic motivation (Luo et al., 2019), curiosity is often included as an interest measurement (Rotgans, 2015).

TABLE 1.6. General Academic Interest Measurements

	Model/ Factor	Items No	Sample	Language
1) Situational Interest (SI) Scale (Garcia et al., 2010)	Model: Triggered-SI, Maintained-SI-Feeling, and Maintained-SI-Value	8	Undergraduate students Adolescents in Grades from 7 to 12	English
2) Individual Interest Scale(Rotgans, 2015)	Cognitive Engagement, Curiosity, Enjoyment, Self-efficacy, Attention, and Boredom	7	High school students	English
3) Global Academic Interest Scale (Lee & Durksen, 2020)	Passion for learning, Confidence in the future, Career aspiration, and Self-expression	15	Graduate students Undergraduate students	English
4) Academic Interest Scale (Luo, et al., 2019)	Emotion, Value, Knowledge, and Engagement	29	Junior high school students	English Chinese

1.7. Current Study

As we have seen above, curiosity and interest could not be well distinguished theoretically, conceptually, and measured in psychology and education. Teasing apart curiosity and interest in an experimental setting, where theories and measurements are presented, is not an easy task. There is needed conceptual clarity by extending bottom-up approaches to consensus the construct of curiosity and interest and thoroughly researching the limitations of prior investigations. Despite the number of validated measurements in the field of psychology and education, there is no agreed-upon measurement for curiosity and interest. Besides, curiosity and interest sometimes have a nested relationship (i.e. interest is part of curiosity). Both constructs have been used to confirm validity of the other construct with each other.

To address this critical issue, we adopt the reward-learning framework of knowledge acquisition as the first step. According to the framework, curiosity and interest are naïve concepts arising from subjective experiences produced by the underlying reward-learning processes (explained in more detail later). As such, the distinction between curiosity and interest should be best examined by the subjective consensus of naïve people. In addition, measurements that assess curiosity and interest should focus more on rewarding experiences of knowledge acquisition themselves, rather than the peripheral properties of them. This project aims to examine (1) the distinction between curiosity and interest, and (2) develop a new measurement assessing them based on the reward learning framework of knowledge acquisition.

The overall structure of the dissertation takes the form of five chapters, including this introductory chapter. Chapter two begins by laying out the qualitative perspective of the research, and looks at how people's naïve beliefs about curiosity and interest. The third

chapter presents the development of a new scale, which are namely the Curiosity and Interest as Rewarding Felling scale (CIRF) based on the reward learning model. Chapter three focuses on the construct validity of the CIRF by examining its relationship with other related variables in the two studies. The final chapter draws upon the entire thesis, tying up the empirical findings that I observed in the empirical chapters. The last chapter also includes a discussion of the implication of the findings to future research into this area.

2 Chapter 2: People's Naïve Belief about Curiosity and Interest: A Qualitative Study

2.1.Introduction

Distinguishing curiosity and interest is the subject of much discussion. One common perspective is that curiosity is a momentary motivation to explore novel or puzzling phenomena (Berlyne, 1960; Silvia, 2017), whereas interest represents a more long-term developmental process, with emphasis on its stability in personality (Hidi, 1990). In other words, curiosity is sometimes conceptualized as immediate experiences in response to stimuli in the external environment (e.g., novel puzzles) while interest represents more active engagement within a learning context (Hidi & Renninger, 2006). However, it is still unclear how in-the-moment experiences generated from interest (often called situational interest) are related to curiosity. In addition, this idea does not clearly explain how trait-level curiosity (i.e., trait curiosity; Litman, 2008) is distinguished from developed interest. As noted by Ainley, shared underlying characteristics of curiosity and interest (e.g., attentional processes and exploratory behaviour) are intertangled in infancy and early childhood; however, the experiential states associated with trait curiosity and interest diverge in later educational contexts (Ainley, 2019).

Another discussion about curiosity and interest concerns whether they are instinctive (externally instigated by one's environment) or intentional (internally instigated) (Alexander, 2019). While children's curiosity is characterised as an exploratory behaviour, especially between ages 4 and 6 years, individual interests (dispositions towards reengaging with specific topics) do not arise until adolescence or adulthood (Alexander, et al., 2008). From childhood to adulthood therefore, curiosity and interest have been reflected differently: in childhood curiosity is viewed as instinctive exploratory behaviour in response to external stimuli, and in adulthood interest is seen as intentional, self-motivated exploration. However, Peterson and Cohen define domain-specific curiosity as an active and intentional experience (Peterson & Cohen, 2019) and curiosity is defined as a conscious investigation and unspecified exploration

of the environment (Murayama, et al., 2019). Therefore, the terms can both be used to refer to intentional, internally motivated behaviour or instinctive, externally motivated behaviour.

The long-lasting debate, disagreement, and confusion about the definition of curiosity and interest poses a fundamental question: *Why* is it so difficult to define curiosity and/or interest? According to the reward-learning framework of knowledge acquisition (Murayama, et al., 2019), curiosity and interest are subjective psychological constructions of underlying mental and neural processes. The framework indicates that people's curiosity- or interest-related behaviour can be explained by a reward-learning process of knowledge acquisition, but the constructs of curiosity and interest do not necessarily exist as elements of this reward-learning process. In fact, people do not typically have direct access to the reward-learning process underlying knowledge acquisition behaviour. However, the underlying reward-learning process produces a myriad of subjective experiences, and from these subjective feelings, people psychologically "construct" various concepts/languages that are useful to explain their subjective feelings and behaviour (Murayama, 2019). Curiosity and interest are considered as two such concepts/languages.

This framework effectively explains the fundamental difficulty of defining curiosity and interest: They are hard to define because curiosity and interest are overly subjective categorization of ambiguous feelings. In fact, curiosity and interest are naïve concepts that laypeople have used long before the scientific investigation of these concepts started. Like much other lay language (e.g. "enjoyment") such naïve terms do not have to have strict scientific definitions. Therefore, we should not expect that there are *correct* definitions of curiosity and interest.

At the same time however, these terms are developed separately in daily language. It is likely that this results from people having qualitatively different feelings relating to knowledge acquisition, i.e., different experiences of their knowledge acquisition process. Our daily

language does not develop in a vacuum --- if lay people can distinguish two concepts, there is good possibility that these two concepts are supported by qualitatively different psychological processes (Murayama, et al., 2019). Therefore, although lay people do not have direct access to precise mental processes, scrutinizing lay people's definitions of curiosity and interest may provide us with some insights into how the knowledge acquisition process is organized in our mind. Examining lay perspectives may also provide scientific researchers with a good basis to establish agreed-upon scientific conceptualizations of curiosity and interest if they wish. In fact, if scientific definitions of curiosity and interest deviate substantially from what lay people believe they are, researchers (especially researchers in applied fields) would have difficulty in effectively communicating their ideas with the general public. In that case, there is no logical reason for researchers to label them as curiosity and interest (i.e., researchers should use different technical terminologies).

The purpose of this chapter is to conduct a preliminary and exploratory investigation on how laypeople define curiosity and interest. We asked participants to define curiosity and interest in their own words, and examined the similarities and differences of these terms in a bottom-up manner. Although there are several studies that examined people's perceptions about curiosity/interest (Kashdan, et al., 2013; Post, et al., 2018), no research has yet directly examined potential commonalities and differences in lay people's perception of curiosity and interest. Because participants were not prompted in any other way than the structured open-ended question, whatever responses the participants produced were presumed to represent their psychological reality, without using any follow-up questions. A qualitative approach may be one of the best ways to capture the definition and interpretation from these free texts. Qualitative approaches have become increasingly common in social studies, and researchers have proposed various different methodologies (e.g., pragmatism of the pluralistic approach, interpreting data pluralistically see Frost, et al., 2011). Qualitative techniques provide rich data

to evaluate studies and generate hypotheses (Bryman, 2006) and give researchers an opportunity to understand the concepts deeply (Sofaer, 2002). We used thematic analysis from Braun and Clarke's approach (2006) to ensure an in-depth exploration of the data, whilst enabling the research to capture a breadth and diversity of views.

2.2. Methods

2.2.1. Participants

We recruited 135 U.S. adults (including nine participants recruited in our pilot study) from Amazon's Mechanical Turk (i.e., MTurk) between July and August 2018 (participants were paid $1 for study completion). The data include nine participants from a pilot study. This pilot study was conducted to ensure the quality of the data before running the study with a large number of participants. These participants answered exactly the same questions as participants in the main study. To increase the data quality on MTurk, we put short questions about participants' attention and whether they cheated (i.e., looked up definitions of curiosity/interest) during the study (we emphasized that responses to these questions would not influence payment). In addition, before analysing the data, we checked the quality of participants' responses. As a result, nine participants were excluded for copying and pasting the same responses for multiple questions or admitted to checking the internet to answer questions. Note that there were more six participants who only partially completed the study. After checking the authenticity of their responses, we decided to include these participants in order to make full use of the collected data. Thus, the final sample consisted of 126 participants (48.50% male). Inclusion criteria were that participants were English-speaking, had access to a computer, and lived in the United States. English was the participants' mother tongue with the exception of ten participants, who started to speak English between 1-10 years old. As for their highest educational qualifications, 40.47% had a university undergraduate degree,

18.25% had a postgraduate degree, 13.49% completed GCSEs, 13.49 % completed A levels, and 3.9% indicated that they had no formal education. Ages ranged between 23 and 72 years old, mean of 40.70 years old (*SD* = 11.70). In terms of race/ethnicity (not allowing multiple selections), 66.90% endorsed Caucasian, 4.60% endorsed African-American, 20% endorsed Asian/Pacific Islander, 4.60% endorsed Native American, 2.30% endorsed Hispanic, and 1.60% endorsed other. The data (excluding the pilot data) was also used as part of a separate, quantitative project (Donnellan, et al., 2021) but was not analysed using qualitative methods, and did not utilise responses to all questions used in the current study.

The sample was not representative: convenience sampling was used (Korstjens & Moser, 2018). The sampling enabled different naïve beliefs regarding curiosity and interest to be uncovered (Elfil & Negida, 2017). Theoretical saturation, which refers to the point at which the collection of additional data adds little or nothing new for the study, is broadly accepted to reach sufficient data (Gentles et al., 2015) and external validation (Nascimento et al., 2018) in qualitative research. We recruited 135 participants due to budgetary reasons, and then analysed and checked the data to see whether the data showed thematic saturation (Hennink, 2017) ; it indeed did, and therefore data collection was stopped.

2.2.2. Data Collection

Before starting the study, the participants read and clicked to confirm the consent form on the screen. In the consent form was indicated that their data will be used anonymously for this research. Also, the participants filled the demographic questions without their names after the consent form and their participation numbers was only used in the results. The study description was purposefully vague to prevent demand characteristics. The study description stated “In this study, you will simply answer open questions and a short questionnaire about motivation. The purpose of the study is to understand your naïve perceptions regarding

motivation. Please answer these questions with your own words (please do not check internet etc.), as there is no right answer to these questions. There is no word limit. However, please answer each question with no less than 80 words."

The open-ended questions appeared on the screen after short demographic questions. There were three questions: "How do you define 'curiosity'? (i.e. being curious about X; feeling curious)"; How do you define 'interest'? (i.e. being interested in X; feeling interesting); "What do you think about the similarities and differences between 'curiosity' and 'interest'?". There was no time limit. As can be seen in the instructions, I tried to minimize the potential demand characteristics bias by simply asking these questions in a neutral manner, without suggesting that these concepts are different. The questions were not counterbalanced across participants (i.e., the question order was the same for all participants). When responding to the first question, participants also did not know that they were going to be asked about the other concept (i.e. in the first question, participants were very unlikely to mentally compare these concepts). The data showed that participants used between 80 and 150 words in response to each question, and none of the participants indicated that curiosity and interest are exactly the same concept. This is consistent with our independent data in which only 1% of the participants indicated that curiosity and interest are completely similar on a 5-point Likert scale (Donnellan, et al., 2021).

2.2.3.Data Analysis

The phases of thematic analysis. Braun and Clarke (2006) argued that there are six phases for thematic analysis: (1) Data familiarization; (2) Producing initial codes; (3) Seeking themes; (4) Theme review; (5) Finalizing theme names and definitions; and (6) Reporting. We followed these steps to do thematic analysis. Specifically, in the first phase (i.e. data familiarization), **t**he computer program NVIVO was selected to conduct the thematic analysis

electronically. Then, reading and re-reading took place to become familiar with the data. After that, initial opinions and thoughts were noted in accordance with research questions. In the second phase (i.e., producing initial codes), a systemised approach to coding was used, in accordance with the principals of the constant comparison method in which data are coded and re-coded iteratively and inductively. As for the third phase, the initial codes were revised and regrouped to create more definitive groups, and common categories were finalised and unified around central themes. In the fourth phase, the themes were checked to see if they were coherent and meaningful, and worked at both Level 1 (the coded extracts) and Level 2 (the entire data set). After reviewing the themes, names were generated for each theme to ensure they captured the meaning and clearly contributed to a consistent overarching interpretation of the data in the fifth phase. In the last phase, clear and vivid quotes were selected that best represented or illustrated a particular theme. As an example for the data analysis process, you can see an interim thematic map before the final themes below (see in Section 2.4).

Coding process. The online transcripts were imported into qualitative analysis software (NVivo 12) for thematic analysis based on Braun and Clarke's criteria (2006). There is a lack of connection with any specific ontological or epistemological position in qualitative research; researchers critically apply a post-positivist perspective (Guba et al., 1994). Combined with this perspective, thematic analysis allows for conceptualisation of precise phenomenon and aids qualitative researchers to conduct relatively objective analysis of data (Braun & Clarke, 2006). Braun and Clark's six phase thematic analysis method, which is comprised of constant comparative techniques, was followed (Braun & Clarke, 2006). These phases are summarized in the Appendix. In phase 1, the data was imported to NVIVO software, and then read and re-read the transcripts. In phase 2, line-by-line coding was conducted. After coding, similar information by using abstract labels (*i.e.* ***active mind*** *below)* was grouped. Some labels were chosen directly from the data (*i.e.* ***actively thinking***). For instance, the following two

participants' quotes were coded as actively thinking and trying new experiences (relating to curiosity.

Coding was an inductive and recursive process, with established comparisons applied between and within transcripts. Primarily, we coded both explicit and implicit meanings for all data. As noted above, some of the names for labels were used explicitly in participants' responses *(i.e.* ***curiosity is active feeling)*** but after comparing similar codes, general meanings also generated for the codes *(i.e.* ***interest is stable and long term feeling for deep information)***. For example, when we interpreted the first quote below, it suggested that curiosity is active feeling but interest is a passive feeling. However, when considering both of the following quotes altogether, we can say that the passive feeling relating to interest actually refers to having a stable long term disposition towards in-depth learning. For that reason, we put "stable feeling" instead of "passive feeling" for interest.

> "Interests can also be passive (***interest is passive feeling)***, where someone is content to allow the information to come to them passively, whereas a curious person tends to be a bit more active ***(curiosity is active feeling*****)** in their pursuit of acquiring more knowledge." (Participant 84)
>
> "That is, curiosity can be more short term while an interest is usually more long term for the most part. You will often be curious about something, then when you find out more, that initial reaction might fade ***(curiosity is active and short term feeling)***. With an interest, it is usually something you are more enamoured with and there is a level there beyond curiosity ***(interest is stable and a long term feeling relating to in-depth information)***. It is not something that can be quenched by a simple answer." (Participant 92)

The labelling of codes aimed to capture the differences and similarities of curiosity and interest. In phase 3, the codes were collated into potential themes, which reflected major features and patterns in the data. A mind map was utilized to visualize the relationship of the codes, which helped us come up with appropriate themes. To ensure the validity of codes and themes, during this phase the appropriateness of the coding process was discussed with my

supervisors (Prof Kou Murayama and Dr Dan Jones) who were not involved in coding . Here we considered and discussed alternative interpretations until reaching a consensus on the interpretation of patterns in the data. In phase 4 and 5, themes were reviewed again by examining all codes and themes collectively, and we also produced a thematic map. Prof Kou Murayama and Dr Dan Jones reviewed the tentative themes (Saldaña, 2009). During the review process, we considered and discussed alternative interpretations until reaching a consensus on the interpretation of patterns in the data. In the last step, phase 6, we determined final themes and identified quotations illustrative of each theme (see more information in Section 2.3 and Section 2.4).

2.3.Results

Overview of themes

The participants' interpretations were captured in two main themes regarding the description of curiosity and interest: (1) curiosity is an active feeling and interest is a stable feeling; (2) curiosity is directed toward uncertainty and interest is directed toward certainty when you want to learn (see Fig 2.1). Each theme highlighted a major aspect of the respondents' perspectives on the differences of curiosity and interest; however, there were areas of conceptual overlap, which we will discuss later. Below, I provide an explanation of the themes, along with example quotes.

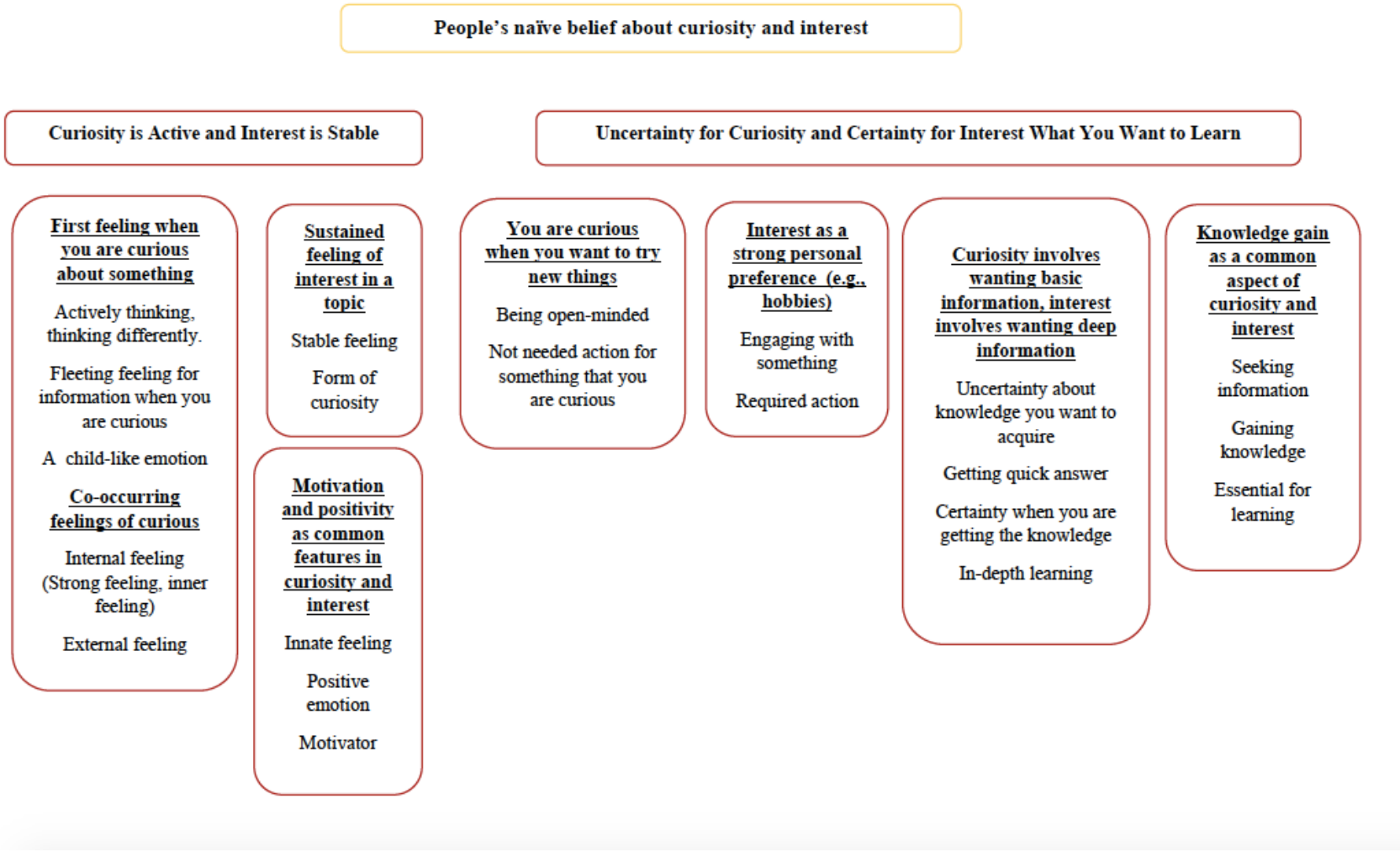

Fig 2.1. Diagram showing the final map

1. Theme: Curiosity is an active feeling and interest is a stable feeling

One theme that arose from participants' responses is that curiosity is an active feeling whereas interest is a stable feeling. The data also indicated that curiosity and interest include common emotions during learning.

> "Curiosity seems like more of an active concept that is impelling you to do something while interest is more of a passive condition." (Participant 109)
>
> "People who are curious try and go and learn about the world, and actively try to engage with other people to help satisfy their thirst for knowledge." (Participant 63)
>
> "Interests can also be passive, where someone is content to allow the information to come to them passively, whereas a curious person tends to be a bit more active in their pursuit of acquiring more knowledge." (Participant2)
>
> " Curiosity: You take a risk to expand your knowledge. Basically, it's an action that you actively do in order to expand your current knowledge from what it was before." (Participant 77)
>
> "Curiosity is what you do when you are doing something active about an interest. Also, curiosity seems to be a stronger feeling than interest. If you are curious about something you are more likely to actually do something, while just being interested seems like it would be easier to ignore at times." (Participant 118)

Sub-theme: Curiosity is the first feeling when you want to know something

Many participants indicated that curiosity was a general active feeling when people acquire information/knowledge and the active feeling generally was associated with eagerness, drive, pursuit, and desire, etc. In addition, participants considered that curiosity represents an initial feeling with active motivation to obtain information or knowledge.

> "Curiosity is typically not a passive feeling, but rather an active pursuit of knowledge or information, so a critical component is that the individual who feels curious must feel compelled or driven." (Participant 83)
>
> "Curiosity appears to be an imaginative and eager emotion which leads one to greater knowledge and broader horizons." (Participant 34)
>
> "You could say that curious comes first then interest. Both the interest and curiosity is about discovery." (Participant 3)
>
> "I think curiosity is what first gets someone involved in a subject and your interest is what keeps a person involved in that subject over a long period of time." (Participant 90)

Furthermore, participants described the mental mind-set of curious people and argued that curious people think differently and actively without being controlled by external forces.

> "I am very curious in education. It makes my mind thinking differently. It's no secret that curiosity makes learning more effective and enjoyable. Curious students not only ask questions, but also actively seek out the answers." (Participant 50)
>
> "It often is good to be curious because it keeps your mind active and you will constantly be thinking about new things and different things and how they all interact. "(Participant 52)
>
> "That uncontrollable sensation that you want to go figure something out, often ignoring the consequences of doing so." (Participant 78)

Participants also indicated that curiosity was different for adults and children, and that curiosity has a child-like nature. Additionally, they described curiosity as a fleeting feeling for information/knowledge. There seems to be a clear connection between the child-like nature of curiosity and other definitions of curiosity such as active thinking and being a fleeting feeling --- these characteristics are generally observed in children's behaviour when exploring environments (i.e. children's attention changes rapidly in response to external stimuli and they tend to get bored quickly).

> "I feel that many more children express curiosity, as opposed to adults. There is also much more of an openness in children which I feel leads to such curiosity. Whereas, with adults we tend to assume we already know enough about just about everything." (Participant 34)
>
> "I feel, is greatly important to both children and adults alike. A healthy interest can give one a sense of purpose." (Participant 34)
>
> "Curiosity can be fleeting, whereas interest is more often sustained." (Participant 6)

Another point that emerged was that curiosity involves both external and internal feelings. In fact, participants emphasized both the external and internal part of feelings in curiosity.

> "We could say that curiosity is something rather external because it was an outside product captured by one of the senses." (Participant 25)
>
> "Curiosity is the inner wondering of how something works, exists or functions." (Participant 112)

Sub-theme: Sustained feeling of interest in a topic

On the other hand, interest was considered to be a passive feeling in comparison to curiosity. Note that the "passive" feeling for interest in the responses was not used negatively: it means that interest is a stable feeling that supports continuous and deep exploration of information without distraction through boredom and other external stimulations in the long term (see the quotations in the Data Analysis). In addition, participants suggested that interest is a form of curiosity, but it is deeper than curiosity. As can be seen in these interpretations, "passive" feelings of curiosity described by participants had positive connotations; interest was defined as a form of curiosity that consolidates your attention and curious behaviour. The passivity of the feeling of interest also helps people spend a long time attending to a topic of interest. In other words, interest is defined as a more stable and slow process that would eventually lead to the deep understanding of information.

> "Interest is a passive action that is innate in a person and unique to them". (Participant 41)

> “Curiosity and interest are similar in the fact that they both define learning about something. Curiosity and interest differ in the sense that curiosity is usually caused more from being nosy and feeling a need to learn; whereas interest is the actual "want" to find out more about something or learn about something .”(Participant 1)
>
> “I personally believe that curiosity and interest are very similar. But, I believe that curiosity is stronger than interest in most cases. Curiosity makes you want to dive in to a thing for subject and learn more. Where interest may be a much milder version of curiosity and you may choose to never take any action on the thing you are interested in at that time. I believe you are more likely to take action about something if you are curious .“(Participant 7)

> “Curiosity is learning about something we may become interested in. I'm a curious person and research things I've never heard of or don't understand. That's curiosity. But pursuing things further after learning about them is creating interest in them and being interested in them. Curiosity can be fleeting, but interest generally demands more time and effort. I was curious about how to can tomatoes .“(Participant 10)

> “Without curiosity we would all just be content in our lives and never develop an interest in anything of the world that we are all a part of. Curiosity is the gentle nudge toward interest. You could thing of interest as the effect and curiosity the cause.” (Participant 19)
>
> “Interest is a form of curiosity that manifests in the interested person being alert and paying attention to a topic, idea, or activity.” (Participant 6)

Moreover, participants gave an analogy with respect to time. From their collective viewpoint, curiosity is a short-term feeling whereas interest is a long-term feeling. This observation is consistent with the other description (mentioned above) that curiosity is a fleeting feeling.

> “That is, curiosity can be more short term while an interest is usually more long term for the most part. You will often be curious about something, then when you find out more, that initial reaction might fade. With an interest, it is usually something you are more enamoured with and there is a level there beyond curiosity. It is not something that can be quenched by a simple answer.” (Participant 92)

Sub-theme: Motivation and positivity as common features in curiosity and interest

Participants indicated that curiosity and interest were both innate feelings and positive emotions (i.e., these were common features). Positive emotions were described in terms of the consequences of knowledge acquisition, experiences and actions.

> "Curiosity is the natural compulsive behaviour of wanting to know about the world. It helps us to learn and to grow when we are younger and figure things out for our own without parents, siblings, or others teaching us things themselves. "(Participant 12)
>
> "Interests are something that are not learned, but natural. This means that just because someone else is interested in a certain thing or topic." (Participant 41)
>
> "They're both usually connected to positive emotions and things that drive people along a certain path of action. They might be different in that curiosity is more of a compulsion that I don't think can be controlled, whereas an interest is more of a general, vague sense that is somewhat optional and doesn't push you to act with the same level of intensity" (Participant 107)
>
> "Being interested in something is typically a positive feeling in which the person will feel good or benefit from gaining additional information about something. Also, interest tends to imply that a person already has at least some small degree of knowledge about the topic they are interested in." (Participant 5)

Participants also noted that curiosity and interest are both motivators for knowledge acquisition.

> "Interest is the state of being motivated to learn about something, to satisfy some personal need or desire." (Participant 13)
>
> "Curiosity has caught your attention and fancy. You think about it and you are motivated to take action." (Participant 21)

2. Theme: Uncertainty for Curiosity and Certainty for Interest When You Want to Learn

This theme captures the different types of approach (i.e. uncertainty orientation and certainty orientation) during knowledge acquisition or information seeking between curiosity and interest.

> "To be curious about something, you don't have a clue about it but if something interests you, you have a reason to be interested because some type of thing caught your attention." (Participant 16)

Sub-theme: You are curious when you want to try new things

Curiosity was commonly associated with risk-taking behaviour and motivation for trying new experiences. Relatedly, participants indicated that curiosity is a personality trait that is related to open-mindedness, gaining knowledge, and personal development.

> "Most people are curious about new information they have learned or curious about something new they have seen." (Participant 19)
>
> "Being curious means having an open mind and seeking more information about something" (Participant 83)
>
> "Curiosity involves risk taking. Interest, on the other hand, is about how creatures are drawn to situations and objects because they have experienced something like them before." (Participant 23)

Sub-theme: Interest as a strong personal preference (e.g., hobbies)

Although interest was sometimes interpreted as a form of curiosity which serves as an initial motivator of information-seeking, participants further noted that interest focused more on task engagement itself. Participants considered interest to be something that requires action to reengage with a topic, and represented more than simply acquiring a piece of information. Interest is referred to as involving sustained actions to know or learn deeply. They associated interest with something akin to hobbies, relationships and things they liked; all supporting the

idea that interest involves long-term engagement and sustained actions. In contrast to curiosity, participants considered that there was little risk-taking associated with interest.

> "Curiosity can be quickly forgotten but when people are interested, they are much more active in pursuing the subject." (Participant 61)
>
> "Interest is when you find yourself constantly thinking about something and you want to know more. Your mind easily turns to that subject, and hearing or reading about it is exciting or at least it takes up a lot of you." (Participant 53)
>
> "Interest is when you want to do more than learn about something; it is when you want to engage with the subject of your interest, as opposed to just learning about it or answering a question regarding it." (Participant 46)
>
> "Interest may also relate to hobbies, relationships, likings, etc. Interest may also lead someone to be more curious into something and how they really want to think about it compared to others." (Participant 88)

Sub-theme: Curiosity involves wanting basic information, interest involves wanting deep knowledge

Participants typically associated curiosity with a feeling elicited by unknown information. Also, curiosity was related to a search for some missing knowledge or the solution to a mystery.

When participants compared curiosity and interest in terms of its relations to learning, interest was associated with a deep understanding and in-depth thoughts about information; conversely, curiosity was more related to the pursuit of a simple answer and immediate knowledge.

> "..but curious is a stronger desire to know about something that it may be just a simple answer. Interest may be something deeper and wanting to know more and more about things."(Participant 108)

Sub-theme: Knowledge gain as a common aspect of curiosity and interest

A common theme of interest and curiosity was the process of gaining knowledge through seeking information. In addition, participants indicated that both terms were understood as essential for learning.

> "Curiosity is the desire to gain knowledge and information about any given topic."(Participant 6)
>
> "Interest is the act of seeking out the answer of something, not being satisfied with what you see on the surface and wanting to know more of what lies within it." (Participant 46)
>
> "Curiosity and interest are similar in the fact that they both define learning about something." (Participant 19)
>
> "A curious person always gain some knowledge from any source and is quite knowledgeable." (Participant 2)
>
> "If the person has an interest in any subject or topic he will be curious and eager to learn the thing, so both have a great relation between them. Interest motivates a person to learn and make him curious to learn things. They both differ in their outcomes. Curiosity is an involuntary desire while interest is a voluntary action. The result of curiosity is not always good while interest always result in good knowledge." (Participant 40)
>
> "Being curious makes me want to look in to something and gain more information and knowledge about it." (Participant 5)
>
> "To me interest is similar to curiosity in that you want more knowledge about something or someone." (Participant 16)

Connection between the themes

We considered potential connections between the two themes. Theme 1 encapsulated the different feelings (active/stable feeling) of curiosity and interest when acquiring knowledge. Theme 2 mainly focused on the feelings relating to anticipating/receiving information (certainty/uncertainty). As well as the themes have showed the distinctions of curiosity and interest, each of the themes have presented the strength of their commonalities

(see Fig 2.2). This suggests that theme 1 and theme 2 seem to capture different stages of the same information-seeking process.

2.4. Discussion

This chapter aimed to understand naïve participants' beliefs about curiosity and interest. Although the terms are often considered to be separate concepts, the subjective experience of each term by naïve participants has not been examined in the literature --- while experts and self-report scales defined these terms based on their own theoretical perspectives, relatively little is known about their natural meaning, discourse, and how they are described by naïve participants. The present results indicate that people ascribe somewhat distinct experiences to curiosity and interest. For example, while curiosity is considered to be active feelings towards uncertainty, interest is considered to be a more stable feeling than curiosity, which is more oriented towards certain things. We also found substantial overlap between the terms, e.g., both terms are closely related to knowledge acquisition process. These results suggest that the human knowledge-acquisition process may be organized in two different parts/stages, and a comprehensive account of information-seeking behaviour requires the consideration of both of these aspects (Murayama et al., 2019). In addition, the generated themes in the present research may help researchers establish agreed-upon scientific definitions that do not considerably deviate from people's naïve understanding. This is not a trivial issue for applied researchers who are in constant communication with the general public.

Our results suggest that curiosity is an active feeling which is further characterized as active thinking, a fleeting feeling that is the first feeling one experiences when confronted with an information gap, and a child-like emotion. This characterisation of curiosity supports previous theories of curiosity. Regarding curiosity as an active feeling, Berlyne classified

curiosity with a four-way categorization in two dimensions (epistemic-perceptual curiosity and diversive-specific curiosity) (Berlyne, 1960). These dimensions implicitly include active feelings, e.g., desire for change, seeking of stimulation, boredom, novelty and desire for knowledge. While Berlyne did not consider the intensity and frequency of feeling, the State-Trait Curiosity Inventory (STCI) did (though the item was "I feel mentally active"; Litman, et al., 2005). Other researchers focus on similar active feelings of curiosity, e.g., the researchers (Kashdan et al., 2009), who proposed that practically curiosity involves acting and thinking differently to provide an intense desire to discover and engage in novel and challenging experiences. Regarding curiosity as a child-like emotion, Jirout and Klahr (2012) emphasized that curiosity in children is characterised as a natural feeling to discover the world. Additionally, they state while children's curiosity is instinctive (i.e., not under intentional control), this is different to adults' curiosity, which can be intentionally directed in order to adapt to new situations (Jirout & Klahr, 2012). Likewise, some researchers have linked curiosity with patterns of infant behavior where they attend to objects with specific physical properties like bright colors, sounds, human face and movement (Fantz, 1961) and also novel objects (even when they have little no prior interaction with these objects, Ainley, 2019).

Interest was associated with certainty about information that someone wanted to learn (i.e., people are interested in information related to something which they know a piece of information about), whereas curiosity was associated with uncertainty (i.e., people are curious about information related to something they do not know about). In the knowledge-gap model (Loewenstein, 1994), curiosity resulted from the realisation that a piece of information was unknown. According to this account, curiosity is discussed in relation to exploration, uncertainty, tolerance of ambiguity, frustration and sensation seeking (Kashdan et al., 2018). Supporting links between uncertainty and curiosity, there is agreement that curiosity is involved in risk-taking, trying new experiences and immersing oneself in situations with

potential for new information or knowledge (Zuckerman, 1979; Renner, 2006; Silvia, 2017), while interest is involved in behaviour that interacts with one's current environment (Fredrickson,1998). Moreover, interest supports people engaging with a diverse set of experiences long term, allowing people to reflect themselves in their current environment (Silvia, 2006). In contrast, curiosity (as openness to experience, novelty seeking and intrinsic motivation) allows people to grow through exploration (Berlyne, 1966; Guba & Lincoln, 1994; Kashdan et al., 2018).

This chapter investigated the naïve beliefs of people about the definition of curiosity and interest. Participants' viewpoints revealed associations between the terms with active/stable feelings and uncertainty/certainty when you acquire new knowledge. Curiosity was considered active, was often equated to a child-like emotion, was a first feeling and a fleeting feeling. Interest was considered a sustainable and grounded feeling. Furthermore, we showed connections between uncertainty and curiosity when acquiring knowledge and found that curiosity was somewhat related to risk-taking behaviour, trying new experiences, and wanting basic knowledge in something. In contrast, we showed connections between certainty and interest, and found that interest was related to long-term engagement with something, showing effort and action towards acquiring and sustaining knowledge over time. Although there are differences between curiosity and interest, the terms overlap in that they are both positive emotions, motivations, relate to acquiring knowledge and are both considered essential for learning (i.e., curiosity sparked further interest). Furthermore, curiosity and interest are different for adults and children. Specifically, curiosity and interest encourage individuals to improve and adapt to their environment.

It is also clear that the terms are complementary and are likely to work in tandem; curiosity allows individuals to discover information and interest allows the consolidation and maintenance of that knowledge. While knowledge acquisition, motivation, and positive

emotions show the common features of curiosity and interest, their distinctions have supported to understand them together. For example, the first theme indicates the changes of emotions regarding curiosity and interest during knowledge acquisition process (see Fig 2.2). This will help researchers to understand and consider peoples' naïve belief about curiosity and interest when designing experiments in this field. Besides, the results have supported for the theoretical perspective of the reward-learning model. The reward-learning model essentially suggests that curiosity and interest are not separable constructs and they are part of the same reward-learning processes of knowledge acquisition (see the model in Introduction). This study encourages to understand the field of curiosity and interest research by clarifying the role of reward-learning in thinking about the constructs of curiosity and interest. Following study, curiosity and interest will be evaluated in one scale to understand the rewarding feeling of knowledge acquisition.

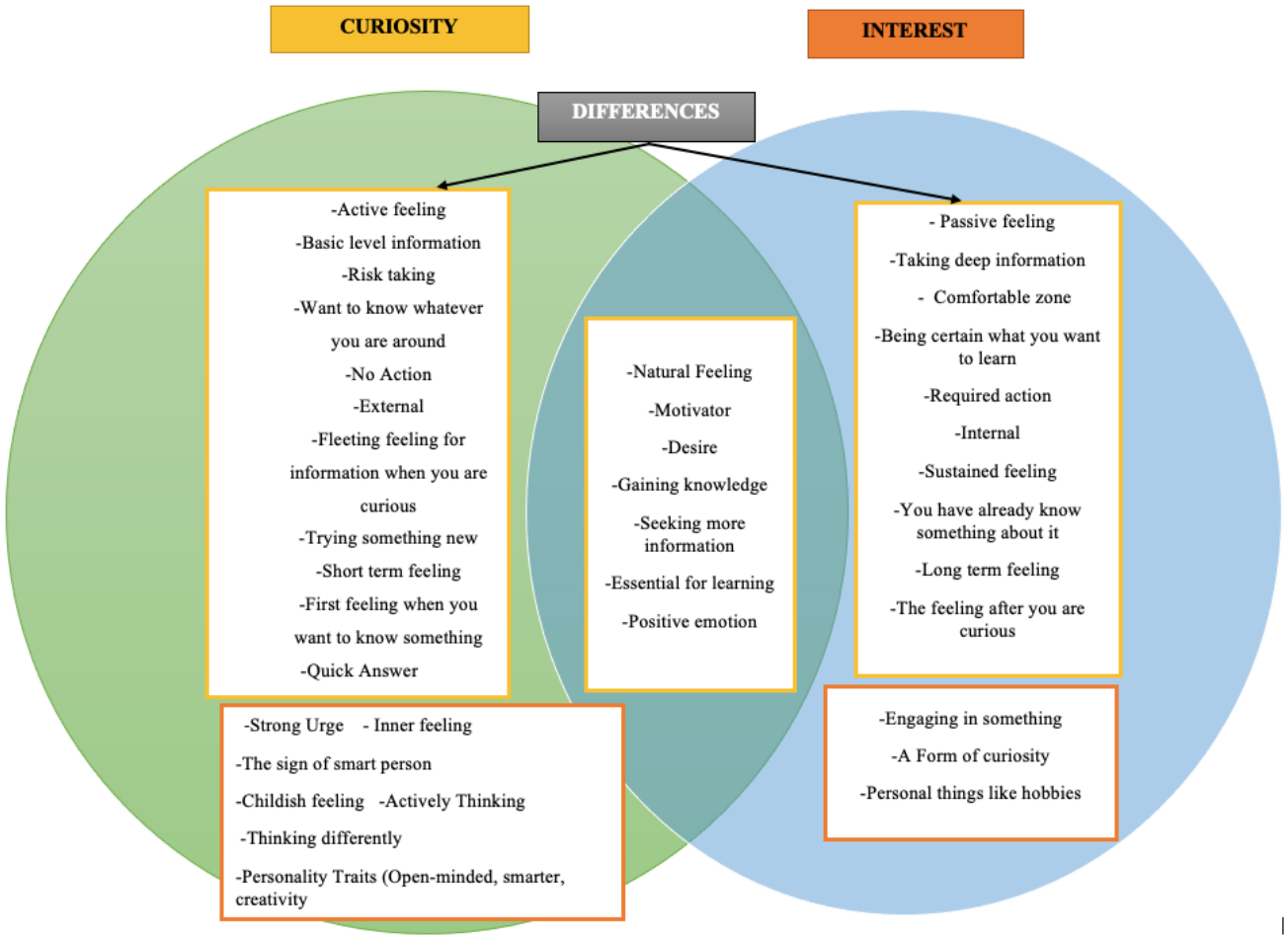

Fig 2.2. The first mind map before the final themes

3 Chapter 3: Development of a Curiosity and Interest as Rewarding Feeling Scale Based on a Reward-Learning Model

3.1. Introduction

The previous study has demonstrated the distinctions and similarities of curiosity and interest. The results presented that curiosity and interest are in the same knowledge acquisition process, showing similarities even if the level of information, the different categorisation of the knowledge gap, and emotions have been indicated differently regarding curiosity and interest in the distinctions. This study has encouraged a grounding of the current theoretical discussion on the reward-learning model (see Section 2.3). As the model has been supported along with reinforcement learning, incentive salience of learning and the rewarding feeling of knowledge acquisition, it could be enabled to understand the nature of curiosity and interest together in light of the rewarding feeling of the knowledge acquisition process. In this chapter, a scale based on the reward-learning model will be developed, and a focus on curiosity and interest will be turned together into a rewarding feeling of knowledge acquisition. Prior to the development of the new scale, previous curiosity and interest scales are reviewed below.

Curiosity and interest are critical components in motivation; they play an essential role in daily life from both a professional and educational perspective. Over the past decade, many educators and academicians have emphasised the importance of interest and curiosity in motivation (Ainley, 2019; Alexander, 2019; Grossnickle, 2014; Lindholm, 2018; Litman and Spielberger 2003; Loewenstein 1994; Murayama et al., 2019; Piotrowski et al. 2014; Savickas & Spokane, 1999; Schraw et al., 2001; White, 1959). Many educational programmes have also focused on interest and curiosity to enhance student motivation (Arnone et al., 2011; Claxton & Carr 2004; Day, 1982; Engel 2011; Hulleman et al., 2008; Jirout & Klahr 2012; McNay, 1985). While these constructs have positive effects on self-regulation, self-esteem and academic performance, and act as a driving force for child development and persistence (Hidi, 1990; Neblett et al., 2006; Sansone et al., 2010; Stern, 1973; Wavo, 2004), as well as willingness to learn new information (Kang et al., 2009; Kashdan and Yuen 2007), it is still

critical for educators to define and assess curiosity and interest to effectively support students in classrooms.

There are several curiosity scales with different orientations (see Section 1.5). For instance, curiosity was examined by a study that developed a ten-item scale that determined feelings of both interest and deprivation epistemic curiosity, named the Interest- and Deprivation-Type Epistemic Curiosity Scale (Litman & Mussel, 2013). The scale suggests two reactions towards novelty that support an individual's motivation and exploration of a subject; interest that provides pleasurable feelings, and deprivation that appears as an aversive feeling from uncertainty. Spielberg (1979) also examined the curiosity aspects of state and trait personality on a ten-item scale, and Naylor's (1981) Melbourne Curiosity Inventory considers curiosity as the same dimensional construct. Both scales examine momentary experiences from the environment (*State Curiosity*) and enduring dispositional tendencies of individuals to gain experiences for new knowledge (*Trait Curiosity*). Pearson (1970) and Zuckerman (1979) respectively created both the Novelty Experiencing Scale (20-item) to measure novelty-seeking tendencies based on the biosocial personality model under the four temperaments (novelty-seeking, harm avoidance, reward dependence and persistence) and the three-character traits (self-directedness, cooperativeness, and self-transcendence). However, the Sensation-Seeking Scale (40-item) assesses the seeking-sensation construct that pursues different types of sensations and experiences involving novelty, complexity, and intensity and challenges through risk-taking from a physical, social and legal perspective. Although the scales focus on a broad personality trait, they could be used in an educational setting. For instance, the Novelty Experiencing Scale has subscales of internal/external sensation and internal/external cognitive desires. These sensations and desires are something students frequently experience in education (going into a fantasy before sleeping = *Internal Sensation*; finding out the meaning of unknown words = *External Cognitive*). Another researcher developed the Academic Curiosity Scale (80

'true'/'false' items) in educational settings (Vidler & Rawan, 1974). In summary, many attempts have been made to measure curiosity in a trait-like form than interest, while interest has often been embraced under the concept of curiosity; additionally, there exists no specific scale that measures such terms in an educational setting.

When it comes to interest scales, situational interest (SI) is measured in academic domains; this scale is divided into triggered-SI and maintained-SI, including feeling and value subscales (Linnenbrink-Garcia et al., 2010). Schraw et al. (2001) demonstrated that interest positively predicts students' intrinsic motivation and learning in the classroom. Furthermore, interest is related to a person's attention, goals and levels of learning (Hidi & Renninger, 2006). Aschieri and Durosoni (2015) examined interest and curiosity to validate the Self-Curiosity Attitude-Interest Scale, which considered self-curiosity as cognitive propensity and interest as increasing knowledge of the self in terms of emotional or motivational feeling. The interest scales are developed to measure vocational interests (Gati, 1991), while self-reports measured the level of interest on a given task in the experiments (Renninger &, Hidi, 2011). It is apparent that there are fewer scales concerned with interest in education, and the importance of interest in classrooms is seldom emphasised.

Most of the scales discussed above are designed to be applied to educational settings. However, as Grossnickle (2014) shows, one critical problem is that different researchers conceptualised curiosity and interest differently; thus, the scales of curiosity and interest seem to be inconsistent. To address the current inconsistent conceptualisations of curiosity and interest in the literature, Murayama, FitzGibbon and Sakaki (2019) emphasised the importance of the reward-learning process to understand curiosity and interest, offering that the rewarding feeling is produced by knowledge acquisition, and such feelings empowers other information-seeking behaviour by increasing the expected reward value of new information. Murayama et

al. (2019) showed that this reward-learning framework of knowledge acquisition could provide an integral account for the different conceptualisations of curiosity and interest in the literature.

Based on the reward learning framework perspective, the purpose of this research is to develop a new scale—the Curiosity and Interest as Rewarding Feeling scale (CIRF)—that focuses on the rewarding experience during the knowledge-acquisition process. Such a newly-developed scale can enlighten the importance of considering the rewarding feeling of knowledge acquisition rather than the rather ill-defined distinction between curiosity and interest (see the framework in Section 1.6.).

3.3. Method

3.3.1. Preliminary Item Pool

To capture the broad scope of curiosity and interest, the reward-learning model proposed by Murayama et al. (2019) was used as this research's focus; an initial item pool of 50-100 items were generated based on that model.

3.3.*2*. Participants

To evaluate the quality and structure of these ten items, 720 participants (55.7% female, 41.9% male, 2.4% other), aged between 12 and 79 years (mean=28.29, SD=13.227), were recruited in London's Science Museum as part of the museum's Motivation Science Lab project in 2018 (led by Lily FitzGibbon). Many different experiments were offered that focused on curiosity (e.g., trivia questions, card games, a 'forbidden fruit' game), including an online version of CIRF. The participants chose which experiments they took part in, and were free to cease their involvement at any time; no time limit was given for completion. CIRF was discretionary between other experiments. On occasion, the children's parents helped them complete the experiments.

In terms of the participants' race/ethnicity (with multiple selections allowed), 76.9% classed themselves as White, 9% as Asian or Asian British, 3% as Black or Black British, 1.3% as Chinese, and 9.8% identified as an 'other' ethnic group or did not state their race/ethnicity (see Table 3.1).

Table 3.1. Descriptive Statistic of the Demographic Information

Gender (N-720)	Age	Ethnicity
55.7% Female	12-79 years	76.9% White
41.9% Male		9% Asian or Asian British
2.4% Other or Not Stated		3% Black or Black British
		9.8% Other Ethnic Group or Not Stated

3.3.3. Instrument

Based on a reward-learning model of interest and curiosity (Murayama et al., 2019), a scale examining the rewarding feeling during knowledge acquisition was developed. Initial discussions were held focusing on the clarity and usefulness of these items from the model's perspective. Based on the model, problematic items were identified and refined; the items were often edited to enhance grammar and to reduce the reading level to appeal to a broad age group. Redundant and ambiguous wording was also checked for conceptual clarity. Ultimately, a native speaker finalised the items so that participants from a wide range of age groups could understand what was being asked. For example, one item was previously written as "I feel pleasant to learn something new"; this item was adapted to "It feels pleasant to learn something new" to embrace the language naturally. Eventually, a scale consisting of ten items was developed.

With the reward-learning framework (Murayama et al., 2019), curiosity and interest are conceptualised with the knowledge-acquisition process. Critically, the model's focus is on autonomous knowledge acquisition based on reward learning; no distinction is given between

curiosity and interest. In the current literature, the definitions of *curiosity* and *interest* are considered as a desire of seeking information, need for knowledge, surprise, engaging with something, and intensive attention. These conceptualisations of curiosity and interest in the theories could be all explained by subcomponents of reward-learning processes (Murayama et al., 2019). The initial items were prepared by following these reward-learning processes, so that the items represented broadly cover rewarding feeling of knowledge acquisition and expected reward value of new information the entire reward-learning process.

Table 3.2. The two factors of the scale

Rewarding Feeling of Knowledge acquisition	Expected reward Value of New knowledge
It feels pleasant to learn something new	When learning something, I like thinking about what I will know at the end of it
I feel rewarded when I understand the things I did not know before	I expect positive feelings when learning new material
I enjoy discovering new information	If there is anything that I do not know, I cannot stop thinking about it
Getting a new knowledge feels addictive	I am impatient when waiting to learn new facts
I have a strong desire for knowledge	Whatever I learn, I feel like I crave new knowledge

The final ten items consisted of two subcategories: Rewarding feeling for knowledge acquisition (e.g., "It feels pleasant to learn something new") and incentive salience of knowledge acquisition (e.g., "I like making an effort even if it is very difficult to achieve something"). Participants rated these items on a seven-point Likert scale, where 1 = 'strongly disagree' and 7 = 'strongly agree'.

3.3.4. Procedure

The data collection period for this survey was 7th August—15th September 2018. A stand was set up, which included computers, large posters detailing the Science Museum's project (titled 'Understanding Curiosity'). Painting kits were prepared for children to raise their

curiosity; e.g., brain painting, or drawing sheets starting with 'I am curious about...' for children to freely create any image they wanted. Eventually, all the paintings were put up on the wall so that they could be seen by others completing the experiment. Generally, participants were invited to the project; the research aims were explained, as was the experiment's procedure. Some of the participants attended as a family with their children, which provided some social and natural positive interactions. Thanks to the interaction, most spent a long time with the experiments. Participants completed the survey using a computer.

3.3.5. Statistical Analyses

Confirmatory factor analysis (CFA) was applied to determine the factorial structure of the items (Harrington, 2009). We used CFA because we have a theoretical hypothesis about the factor structure of the items. The CFA was first applied to the data to determine the overall factor structure. Next, the multigroup CFAs were applied to examine the similarities and differences of the factor structure between schoolchildren-adults and female-male. Specifically, multigroup CFAs were used to examine the configural invariance model, metric invariance model and error invariance model**.** ANOVA was applied to examine the difference between age and gender.

3.4. Results

A series of CFAs were applied. As noted by Shek and Yu (2014), CFA determines the ability of a described factor model to explain the observed data. Parameter estimates are based on the maximum likelihood method. According to standard practice (Harrington, 2009), the fit was deemed acceptable with a Comparative Fit Index (CFI) of ≥ .90, a Tucker-Lewis Index (TLI) of ≥ .90 and a root mean square error of approximation (RMSEA) of < 0.08.

Table 3.3 shows the model fit and factor correlation in three models, which were modified step-by-step.

Table 3. 3. The result of CFA about the Model

Model Fit						
Models	X^2	*df*	**TLI**	**CFI**	**RMESA**	**Factor Correlation**
Model 1(2 Factor-10 Item)	241.874	42	0.89	0.92	0.083	0.98
Model 2(1 Factor-10 Item)	164.833	35	0.91	0.93	0.073	*
Model 3(1 Factor-9 Item)	141.154	27	0.92	0.94	0.078	*

Note: df =degrees of freedom; Comparative fit index; TLI=Tucker-Lewis index; RMSEA=root mean square error of approximation. All chi-square values were scale corrected. To calculate the differences in model

Firstly, as mentioned above (see Section 3.3), a 10-item version was first used when a two-factor model (rewarding feeling of the acquisition of knowledge and expected reward value of new information) was applied to the data (Model 1). Since this model exhibited a high correlation between the factors (0.98), a one-factor model was fit to the ten-item version (Model 2). This model showed a good fit to the data, but one item had a low factor loading (0.31). Consequently, it was decided that this item would be dropped ("I am impatient when waiting to learn new facts"), resulting in a nine-item version of the scale. This model presented a good fit [X^2(27, N =715) =141.154, CFI=.941, TLI=.921, RMSEA=.078].

To examine the potential age group differences in the factor structure of this nine-item scale, the multigroup CFAs were applied between schoolchildren (N= 135, N_{age}= 12-17) and adults (N=585, N_{age}= 18-79) to test factorial invariance, metric invariance and error invariance models (see Table 3.3). Harrington (2009) notes that configural invariance examines whether the instrument works differently for different groups.

Table 3.4. Model Tested of the Factor Structure across the Two Samples

	Model Fit				
Models	X^2	*df*	**TLI**	**CFI**	**RMESA**
Factorial Invariance	199.962	54	0.89	0.92	0.06
Metric Invariance	215.455	63	0.91	0.92	0.05
Error Invariance	288.926	72	0.88	0.89	0.06

Note: df =degrees of freedom; Comparative fit index; TLI=Tucker-Lewis index; RMSEA=root mean square error of approximation. All chi- square values were scale corrected. To calculate the differences in model

As seen in Table 3.4, the first model (Factorial Invariance) shows a good fit [X^2(54, N=720)=199.962, CFI=.92, TLI=.89, RMSEA=.06]. However, metric invariance [X^2(63, N =720) =215.455, CFI=.92, TLI=.91, RMSEA=.05] presents a better fit than both the factorial invariance model and the error invariance model [X^2(72, N =720) =288.926, CFI=.89, TLI=.88, RMSEA=.06]. To summarise, the metric invariance model exhibits a good fit compared to other models, so this model was chosen. Therefore, unstandardised factor loadings are the same across the age groups, while error invariance shows a slight difference. Table 3.4 presents the final items and the standardised factor loadings.

Table 3.5. Metric Invariance the Standardized Factor Loading for Each Group and Their Descriptive Statistic

Item	Factors	Adults (N=585)			Schoolchildren (N=135)		
		Factor Loading	Mean	SD	Factor loading	Mean	SD
It feels pleasant to learn something new	RF	0.59	5.43	0.78	0.55	5.17	0.85
When learning something, I like thinking about what I will know at the end of it	ERV	0.48	4.53	1.19	0.44	4.02	1.43
I feel rewarded when I understand the things I did not know before	RF	0.6	5.38	0.78	0.52	5.1	0.94
I enjoy discovering new information	RF	0.73	5.24	0.8	0.63	4.98	0.92
I expect positive feelings when learning new material	ERV	0.45	4.59	1.12	0.42	4.17	1.23
If there is anything that I do not know, I cannot stop thinking about it	ERV	0.48	4.14	1.34	0.46	4.17	1.33
Getting a new knowledge feels addictive	RF	0.77	4.74	1.09	0.66	4.25	1.32
I have a strong desire for knowledge	RF	0.79	5	1.01	0.71	4.58	1.18
Whatever I learn, I feel like I crave new knowledge	RF	0.66	4.38	1.13	0.66	3.85	1.25

***The result of Metric Invariance for standardized estimates**
Rewarding feeling of the acquisition of knowledge (RF)
Expected reward value of new information (ERV)

As evidenced by Table 3.5, the items reveal similar standardised factor loadings between schoolchildren and adults (e.g., "I have a strong desire for knowledge" [adults =0.59; schoolchildren =0.55]). Note that while unstandardised factor loadings are deemed equal with the metric invariance model, standardised factor loadings can differ as error variances can vary. This result suggests that the scale applies to both age groups**.**

Multigroup CFAs were used to examine potential gender differences in the scale's factor structure between females and males. For that, configural invariance, metric invariance and error invariance models (see Table 3.5).

Table 3.6. Model Tested of the Factor Structure across the Two Samples (Female and Male)

	Model Fit				
	X^2	**df**	**CFI**	**TLI**	**RMSEA**
1. Configural Invariance	145.698	54	0.95	0.93	0.05
2. Metric Invariance	161.323	63	0.94	0.94	0.04
3. Error Invariance	177.410	72	0.94	0.94	0.04

From the table, error invariance model shows a good fit [X^2(72, N =720) =177.410, CFI=.94, TLI=.94, RMSEA=.04]. Also, metric invariance [X^2(63, N =720) =161.323, CFI=.94, TLI=.94, RMSEA=.04] provides a better fit than the configural invariance model [X^2(54, N =720) =145.698, CFI=.95, TLI=.93, RMSEA=.05]. Overall, these results indicate that the error invariance model demonstrated a good fit compared to other models, so this model was chosen. The three models present that the unstandardised factor loadings are the same for gender, but error invariance is slightly better than the others. Table 3.7 shows the items and the standardised loadings for females and males.

Table 3.7. Error Invariance the Standardized Factor Loading for Each Group and Their Descriptive Statistic

	Female (N=398)			Male (N=294)	
Item	**Factor Loading**	**Mean**	**SD**	**Mean**	**SD**
It feels pleasant to learn something new	0.56	5.38	0.59	5.34	0.68
When learning something, I like thinking about what I will know at the end of it	0.5	4.47	1.19	4.33	1.2
I feel rewarded when I understand the things I did not know before	0.56	5.37	0.79	5.21	0.68
I enjoy discovering new information	0.68	5.23	0.79	5.09	0.68
I expect positive feelings when learning new material	0.49	4.57	0.99	4.34	1.02
If there is anything that I do not know, I cannot stop thinking about it	0.44	4.21	1.19	4.06	1.2
Getting a new knowledge feels addictive	0.74	4.64	0.99	4.58	1.02
I have a strong desire for knowledge	0.76	4.9	0.99	4.86	1.02
Whatever I learn, I feel like I crave new knowledge	0.73	4.23	0.99	4.26	1.02

***The result of Error Invariance for standardized estimates**

To examine whether age and gender are different on CIRF, a 2 (Age) X 2 (Gender) ANOVA was conducted. The main effect of age was found [F (1, 688) = 36, 40, p= .00, η^2=0.05], indicating that the age of the participants demonstrated a statistically significant effect. The main effect of gender was not significant [F (1, 688) = 1, 59, p=.09, η^2=0.005]. Also, the interaction effect was not significant [F (1, 688) = 0.21, p=.64, η^2=0.000] between gender and age on CIRF. The significant main effect of age showed that the rewarding feeling of adults for knowledge

acquisition (M=4.83, SD=0.66) was significantly higher than schoolchildren (M=4.46, SD=0.75) on CIRF. The results have two important implications, the first being that CIRF presented a good fit and factor loadings both age groups and gender in the model. Secondly, although the model supports all age groups, adults exhibit more rewarding feelings towards knowledge acquisition than schoolchildren.

3.5. Discussion

A primary goal of this project was to develop a reliable and valid scale for measuring interest and curiosity based on the rewarding feeling during the knowledge-acquisition process. For the purposes of research, 10 items were administered to 720 participants. By running the CFAs, three models were compared based on model fit; the model with one factor (the rewarding feeling of the acquisition of knowledge) consisting of nine items was selected. Next, CIRF was examined in terms of the potential age differences with three models, namely factorial, metric and error invariance models. Metric invariance showed a good fit when comparing CIRF between adults and schoolchildren.

Additionally, the models were utilised to identify any difference between females and males. While the three models presented good fits, error invariance was slightly better than others. Lastly, the same groups were used to conduct ANOVA to examine potential mean differences. Although the interaction effect was not statistically significant between gender and age, adults exhibited more rewarding feelings towards knowledge acquisition than children. All results indicated that a single factor would be best to represent the rewarding feeling of knowledge acquisition.

The current findings also shed new light on recent studies claiming whether curiosity and interest in the framework can be conceptually measured together or separately. The CFAs results of this study provide reasonable evidence to support the construct validity of CIRF, indicating that curiosity/interest based on information-seeking behaviour can be measured by focusing on a single rewarding feeling of knowledge acquisition, rather than assessing curiosity and interest separately. Although these results reveal some minor deviations from the constructs, overall, the data fits the central underlying assumption of the framework well. The theoretical background of scale construction was based on the reward-learning framework. The

process of curiosity and interest is examined by focusing on the knowledge-acquisition process in the reward-learning model, as opposed to defining the constructs of curiosity and interest separately (see Section General Introduction).

Similarly, Litman and Jimerson (2004) proposed curiosity in two types: a feeling of deprivation during the realisation of knowledge gaps and a feeling of interest when learning new information. Conversely, the measure described here was developed from knowledge gaps to learning something new or more knowledge without any separation of curiosity and interest in the reward-learning model. Rather than separating curiosity and interest, the focus on the model emphasises a general knowledge-acquisition process of curiosity and interest along with wanting (deprivation) and liking (interest). The reward-learning model in the scale could present a more comprehensive perspective by compounding curiosity and interest implicitly in the knowledge-acquisition process.

The results found revealed some high correlation among sub-factors, which were originally assumed, namely the rewarding feeling of the knowledge acquisition and the expected reward value of new information. The good model appears with the rewarding feeling of knowledge acquisition in the one-dimensional factor (i.e., subjective rewarding feeling). These results indicate that, although these two constructs can potentially be different as they represent distinct elements in the process, the self-reported nature of the scale does not allow researchers to distinguish them at the between-person level.

These results could highlight the importance of rewarding feelings in education to understand the curiosity and interest of schoolchildren. The CFA models supported CIRF's use for adults and schoolchildren; also, adults showed more rewarding feelings towards knowledge acquisition than schoolchildren. The discrepancy between adults and schoolchildren might be because of the developmental psychology process. The scale might be examined in a specific educational context to explain children's perception, but the rewarding feeling of children

during the learning process is constantly updated in their immediate different experiences (Murayama et al., 2019). Education researchers tend to use rewards in a narrow sense (i.e., extrinsic incentives) (Deci et al., 1999). By defining rewarding feelings broadly, educators can begin to think about the utility of rewarding feelings towards knowledge acquisition in education; this could promote students' curiosity and interest during the learning process. While the reward-learning model encourages the rewarding feeling from the knowledge acquisition by involving intrinsic and extrinsic rewards, and the CIRF results support a practical, theoretical guideline for future studies.

It is also worth noting that these findings included different cultural populations and age groups (See Table 3.1) attending the Science Museum in London. The diversity of nationality is consistent with the previous findings on the cross-cultural consistency of people's perceived curiosity and interest (Kashdan et al., 2020; Litman & Mussel, 2013). Although there is no intention here to examine cross-cultural differences, this is a topic of study worth considering in future research.

In summary, this study provides evidence for the role of rewarding feelings on knowledge acquisition in the process of curiosity and interest. The findings suggest that the CIRF supports the best-fitting model with one factor. The metric invariance model across adults and children are similar; additionally, all CFA models presented a good fit (error invariance is slightly better than others) for the multigroup analysis with gender, and adults experienced more rewarding feelings towards knowledge acquisition than schoolchildren in this study.

4 Chapter 4: Correlates of the curiosity and interest as rewarding feeling scale

4.1. Introduction

In the previous chapter, the Curiosity and Interest as Rewarding Feeling scale (CIRF)—based on the reward-learning model—was developed using items that focus on the knowledge-acquisition process (see Appendix 1). The reward-learning model (Murayama et al., 2019) presents a meticulous and neural psychological process within the knowledge-acquisition process supporting the common constituents that underpin curiosity and interest (e.g., knowledge gap, information seeking and knowledge acquisition). Curiosity and interest have been examined with studies regarding these constituents for both their definition and measurements (Boscolo et al. 2011; Kang et al. 2009; Kashan & Yuen, 2007; Knobloch et al. 2004; Reio et al. 2006). The model provides an understanding of the underlying processes of curiosity and interest. The results of the new CIRF scale in this framework have shown a significantly good fit for adults/schoolchildren and females/males (see Chapter 3). The present chapter details the construct validities of CIRF. Along with the scales mentioned below, whether CIRF is related to these scales in a theoretically meaningful manner with schoolchildren is examined. The chapter has two sub-studies, both of which are designed to evaluate students' motivation and learning processes with CIRF.

The two specific goals of this chapter are as follows: The first was to evaluate the structural validity of the one-factor, nine-item CIRF identified by the confirmatory factor analysis (CFA) of the previous chapter with a novel sample of respondents. The second goal was to better understand whether CIRF was associated with different ways to define and measure curiosity and interest in students, as part of the construction validation process. In Study 3a, interest, deprivation and risk-taking constructs were examined as correlates of CIRF. For that, the Interest/Deprivation-type curiosity scale and Thrill-Seeking from the Five-Dimensional Curiosity scale (5DC) were chosen. *Interest/Deprivation*-type curiosity refers to trait forms on interest and deprivation feelings of curiosity connected to desiring and seeking

information (Litman & Jimerson, 2004); it is also based on epistemic curiosity, which refers to a desire to know (Grossnickle, 2014; Litman, 2010). As for *Thrill-Seeking*, the 5DC measures curiosity on a multidimensional approach, including linked personality dimensions, emotional states and well-being factors, as well as risk-taking behaviour for the sake of the acquisition of positive emotions; pleasure is measured with Thrill-Seeking (see Kashdan et al., 2018).

According to the framework, CIRF items are generally focused on the rewarding feeling as knowledge acquisition, i.e., learning something from new information (e.g., "I feel rewarded when I understand the things I did not know before"). However, the Interest- and Deprivation-type Curiosity scale based on epistemic curiosity (i.e., a desire for knowledge) examined stimulating pleasurable feelings of *situational interest* for Interest-type (I-type) curiosity (e.g., "I enjoy exploring new ideas") and favourable negative conditions of feeling *deprived* of knowledge for Deprivation-type (D-type) of curiosity (e.g., "try to learn about complex topics") (Litman, 2005). As CIRF highlighted positive rewarding feelings associated with knowledge acquisition, it was hypothesised that CIRF is positively associated with I-type curiosity. The framework and the items of the CIRF focus on the positive feedback loop of knowledge acquisition. Deprivation- and Interest-type curiosity (D-type and I-type) under wanting and liking components that have been examined implicitly within the expected reward value of new information, rather than focusing on feeling deprived of knowledge. The CIRF with a reward-learning framework focuses on interest-based engagement during the knowledge acquisition process; therefore, it was hypothesised that CIRF is negatively associated with D-type curiosity.

Thrill-Seeking, as one of the dimensions of curiosity in the 5DC scale, focuses on taking a risk despite uncertainty and overcoming negative emotions (e.g., "The anxiety of doing something new makes me feel excited and alive" [Kashdan et al., 2018]). These items displayed the strongest correlates with sensation scales (Kashdan et al., 2018). The reward-learning

model evaluates anxiety as one of the moderators that inhibit information-seeking behaviour. As such, it was predicted that Thrill-Seeking is also positively correlated with CIRF.

In Study 3b, interest, motivation, curiosity, achievement motives, rewarding feeling and desire for knowledge were examined for construct validity. For these constructs, the Individual Interest Scale (Hidi & Renninger, 2006), Motivated Strategies for Learning Questionnaire (Duncan & McKeachie, 2005), Expectancy-Value Model of Achievement Motivation Scale by Eccles et al. (1983), Curiosity and Exploration Inventory-II (Kashdan et al., 2004), and the Sensitivity-to-Reward Questionnaire (based on Gray's Reinforcement Sensitive Theory [Conner et al., 2018]) were applied.

To evaluate the construct validity of the newly developed CIRF more extensively, Study 3b focused on several other scales as correlates of CIRF. First, the Individual Interest Scale was chosen to measure interest construct, focusing on schoolchildren in a particular subject. The definition of *individual interest* is explained as an enduring predisposition for objects, events and reengaging with a specific content (Ainley, 2002; Hidi, 2006; Hidi & Renninger, 2006; Krapp, 1999); thus, individual interest in positive emotions provides value and knowledge. Murayama et al. (2019) addressed the phenomenon in a more comprehensive manner by focusing on the knowledge-acquisition process based on the reward-learning model. The framework emphasises how people engage and maintain knowledge gaps, information-seeking behaviour, knowledge acquisition and rewarding feeling (see Chapter 3). As individual interest is a natural part of the reward-learning process, it was expected that it is positively related to CIRF. Another construct for the study was motivation, and the Motivated Strategies for Learning Questionnaire and the Expectancy-Value Model of Achievement Motivation scale were used to assess different types of motivation. Duncan and McKeachie (2005) noted that MSLQ was developed considering a social-cognitive view of motivation and learning strategies incorporating students actively (i.e., their beliefs and cognitions reflect on the nature

of academic tasks). Within the scale, extrinsic and intrinsic motivation subscales were used: *Intrinsic motivation* is referred to as intrinsic goal orientation (e.g., studying for a purpose of learning or internal approval), while *extrinsic motivation* is defined as extrinsic goal orientation (e.g., studying for a high grade or external approval). Critically, although intrinsic and extrinsic motivations are claimed to be governed by distinct motivational processes, it is expected that both intrinsic motivation and extrinsic motivation are positively correlated with CIRF; Murayama et al. (2019) argued that they share the common psychological processes (i.e., reward-learning process), which is the basis for curiosity and interest.

Regarding the Model of Achievement Motivation scale, the Expectancy-Value Model of Achievement Motivation by Eccles et al. (1983) has been adopted, which measures achievement motives built upon the nature of the expectancy and value constructs in students' performance and choice. The scale consists of subscales—*Ability Beliefs*, *Expectancy*, *Usefulness*, *Importance* and *Interest*—and was expected that CIRF is positively correlated with all subscales. For instance, the reward-learning framework indicates that competence belief is a critical moderator that initiates information-seeking behaviour and, as such, it is expected that ability belief and expectancy are both positively related to CIRF. The framework also suggests that valuation is the core component of long-term engagement and, as such, it should be expected that usefulness and importance are positively related to CIRF. Finally, interest is part of the curiosity/interest process, so it is expected that the interest subscale is also positively related to CIRF. *Ability beliefs* are described as the perception of individuals regarding their competence during an activity. *Expectancy* is distinguished from ability beliefs conceptually as it is about the expectancy for current success, even if ability beliefs and expectancy are highly related. In other words, while ability beliefs emphasise present ability, expectancies focus on the future. *Usefulness*, *importance* and *interest* are considered as achievement values (e.g., attainment value, intrinsic value, utility value and cost) within the model: *Attainment*

value is defined as the importance of doing well for a task; *Intrinsic value* defines the importance of a given task with the enjoyment of doing the task; *Utility value* is connected with the usefulness of a task on individuals' plans; *Cost* refers to how individuals engage the decision within an activity (e.g., doing schoolwork, emotional cost). Lastly, *interest* refers to utility and intrinsic values. Due to the distinct theoretical perspectives and different intellectual roots, interest shows some overlap in these constructs.

Study 3b also uses the Curiosity and Exploration Inventory-II to assesses some aspects of curiosity; it focuses on the personal growth facilitation model of curiosity (see Kashdan et al., 2004). Curiosity is evaluated in two dimensions: *exploration/stretching* or seeking out new information or experiences, and *embracing*, which refers to the willingness to engage with novelty and uncertainty in daily life experiences. The knowledge-acquisition process of CIRF has deliberated on seeking information and tolerance for novelty, uncertainty, unpredictability during the knowledge-acquisition process. Therefore, a positive relationship with these subscales was expected.

Finally, the Sensitivity-to-Reward Subscale—based on Gray's Reinforcement Sensitive Theory (Conner et al., 2018)—was also utilised. Gray connected sensitivity-to-reward with a behavioural approach system (BAS), a behavioural inhibition system (BIS) and a fight-flight (FFS) system:

> *The BAS was presumed to be sensitive to conditioned signals of reward or non-punishment and was initially identified with trait impulsivity, while the BIS was presumed to be sensitive to conditioned signals of punishment or frustrative non-reward and was initially identified with trait anxiety. A third system, the FFS, mediated responses to unconditioned aversive stimuli.* (Cooper & Gomez, 2008, p.90).

As reinforcement learning is the core of the reward-learning framework, it was hypothesised that CIRF is related to rewarding feeling—perhaps even stronger than the relationship of CIRF with other variables.

4.2. Study 3a

This study focused on the construct validity of CIRF by using of *Interest/Deprivation*-type curiosity scale and *Thrill-Seeking* from the Five-Dimensional Curiosity scale (5DC) on schoolchildren. CIRF was examined in terms of *interest, deprivation and risk-taking* constructs. It was hypothesised that CIRF would be positively correlated with Interest-type curiosity and the Thrill-Seeking subscale, but not with Deprivation-type curiosity according to the reward-learning model.

4.2.1 Method

4.2.1.1 Participants. A total of 173 (19.1% female, 80.9% male) participants, aged 16-18 years old (mean age = 16.33; SD = 1.8) took part in the study. The participants were recruited in a local sixth form school in the UK as part of a larger project organised by the Motivation Science Lab. The survey data were collected by a computer.

4.2.1.2 Materials and procedure. Each participant responded to the CIRF detailed in Chapter 3. Participants also responded to the Interest/Deprivation-type curiosity scale (developed by Litman & Mussel, 2013) and the Thrill-Seeking subscale from the Five-Dimensional Curiosity scale (5DC; developed by Kashdan et al., 2018). Each questionnaire used in this study shall now be briefly described.

4.2.1.3 Curiosity and Interest as Rewarding Feeling Scale. The newly developed CIRF scale includes nine items (e.g., “I have a strong desire for knowledge”) to examine rewarding feelings during knowledge acquisition. The participants rated these items on a seven-point Likert scale, where 1 = ‘strongly disagree’ and to 7 = ‘strongly agree’. The

measurement based on the model aims to develop curiosity and interest scales in the same knowledge-acquisition process (see Appendix 3). So far, the curiosity literature has been focused on knowledge gaps and seeking information (Ainley, 2019; Grossnickle, 2014; Loewenstein, 1994), while interest research is concerned with the engagement processes in emotional aspects (Alexander, 2019; Silvia, 2006). Curiosity is still considered an essential element of the long-term knowledge-acquisition process, since knowledge as a consequence of numerous curiosity experiences—randomly or not—can provide self-generation of intrinsic rewards and maintain engagement (Murayama et al., 2019).

4.2.1.4. Epistemic curiosity (EC). EC refers to the desire for new knowledge, and the Interest/Deprivation model of curiosity highlighted the distinction between Interest (I-type) and Deprivation (D-type) in EC (Litman & Spielberger, 2003). In a study by Litman (2005), EC is examined from the perspective of stimulating pleasurable situational interest and relaxing negative sentimental conditions of feeling deprived of knowledge, which consisted of ten items and comprised two subscales: Interest- and Deprivation-type of epistemic trait curiosity (e.g., "I enjoy exploring new ideas" [Interest] and "I work like a fiend at problems that I feel must be solved" [Deprivation]; Litman & Mussel, 2013). The scale is assessed on a four-point Likert scale, where 1 = 'rarely' and 4 = 'almost always'(see Appendix 4).

4.2.1.5. Risk-taking. The 5DC scale (Kashdan et al., 2018) is a 25-item instrument that assesses curiosity tendencies across five subcategories: Joyous Exploration, Deprivation Sensitivity, Stress Tolerance, Social Curiosity and Thrill-Seeking. For this study, only Thrill-Seeking is used to examine the construct validity of CIRF. The subscale assesses risk-taking to reach positive emotions and pleasure experiences (e.g. "Risk-taking is exciting to me."). These items were rated on a seven-point Likert scale, where 1 = 'Does not describe me at all' and 7 = 'Completely describes me' (see Appendix 5).

4.2.2. Results

4.2.2.1. Correlations and reliability. The internal consistency of the scales was measured in Table 4.1.

Table 4.1. The Results of Cronbach's Alpha

	N	Item no	α
1.CIRF	173	9	0.85
2. Interest	173	5	0.77
3.Deprivation	173	5	0.81
4.Thrill-Seeking	173	5	0.83

The results of Cronbach's alpha indicated good internal consistency of the items for each of the scales (ranging from 0.77 to 0.85). Gliem and Gliem (2003) presented George and Mallery criteria of Cronbach's alpha values: _ > .9 = Excellent, _ > .8 = Good, _ > .7 = Acceptable, _ > .6 = Questionable, _ > .5 = Poor and_ < .5 = Unacceptable.

In the study, relations between CIRF and Interest/Deprivation-type curiosity, and risk-taking were investigated. Means, SDs, correlations for CIRF, Interest/Deprivation-type curiosity and Thrill-Seeking measures are reported in Table 4.2.

Table 4.2. Means, *SD*, and correlations between CIRF, Interest/Deprivation type of Curiosity scale and Thrill-Seeking scale

Scale (N=173)	Mean	SD	Range	1	2	3	4
1. CIRF	4.81	0.82	1-7	1	0.64**	0.55**	0.32**
2.I- Type Curiosity	2.55	0.53	1-4	0.64**	1	0.53**	0.31**
3.D-Type Curiosity	2.04	0.67	1-4	0.55**	0.53**	1	0.19*
4.Thrill Seeking	4.30	1.29	1-7	0.32**	0.31**	0.19*	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Notes: CIRF= Curiosity and Interest as Rewarding Feeling scale, I- Type Curiosity= Interest Type of Curiosity, D-Type Curiosity= Deprivation Type of Curiosity. *R*'s, p<.05

Correlations between CIRF measure and other curiosity scales were generally moderate to high, with I-type curiosity (r=.64, p<0.01), D-type curiosity (r=.55, p<0.01), and Thrill-Seeking (r=.32, p<0.01). These results indicate that CIRF is correlated with other types of curiosity scales as expected, demonstrating some convergent evidence for the construct validity. The only exception is D-type curiosity, for which a positive correlation with CIRF was not expected; this discrepancy will be discussed later.

4.2.2.2. Regression analysis. To further examine the relationship between CIRF and other constructs in a more comprehensive manner, a regression analysis was conducted to predict CIRF from the other scales controlling for gender. Although CIRF was predicted with all measured variables, I-type curiosity (standardised β=.45, p<.001) turned out to be a particularly strong predictor. D-type curiosity (standardised β=.29, p<.001) and Thrill-Seeking (standardised β=.12, p=0.03) also showed a contribution to predicting CIRF. All the predictors produced R^2 =.48, $F(3, 173)$= 52.90, p=.000 for CIRF. To summarise, CIRF is shown to be positively related to I-type curiosity, D-type curiosity and Thrill-Seeking, but no statistically significant relations were found with gender. The correlation and regression results supported that I-type curiosity may be the most similar construct with CIRF compared to D-type curiosity and Thrill-Seeking for CIRF.

4.2.2.3. Confirmatory Factor Analysis. Chapter 3 detailed the factorial validity of CIRF, but to examine the robustness of the factorial structure of the scale, the CFA was applied using IBM SPSS Amos software. As noted by Byrne (2016), the CFA determines the ability of a described factor model to explain the observed data. The maximum likelihood method and the standard practice were used. The recommended three-index strategy was used to assess fit, with values greater than .95 for the Comparative Fit Index (CFI) and .90 for the Tucker-Lewis Index (TLI) and less than .08 for the root mean square error of approximation (RMSEA), which indicates a good fit (Hu & Bentler, 1999)**.** Unlike the previous empirical chapter, this model

did not show a good fit, [X^2(27, N =173)=78.46, *CFI*=.91, *TLI*=.88, *RMSEA*=.10], although factor loadings are all satisfactorily high (See Table 4.3).

Table 4.3. Confirmatory Factor Analysis (CFA) Results for the CIRF

Item (N=173)	Factor Loading
It feels pleasant to learn something new	0.67
When learning something, I like thinking about what I will know at the end of it	0.46
I feel rewarded when I understand the things I did not know before	0.76
I enjoy discovering new information	0.42
I expect positive feelings when learning new material	0.74
If there is anything that I do not know, I cannot stop thinking about it	0.54
Getting a new knowledge feels addictive	0.74
I have a strong desire for knowledge	0.81
Whatever I learn, I feel like I crave new knowledge	0.50

The series of analysis assesses the construct validity and the factorial structure of CIRF. I-type curiosity was significantly correlated and associated with CIRF, yet D-type curiosity and Thrill-Seeking also confirmed significantly positive relations for CIRF. Although no good fit was found for CIRF, factor loadings are still all high, which indicates the single-factor structure (perhaps with unspecified correlated errors, which brought down the fit).

4.3. Study 3b

This study examined the validity of CIRF in accordance with individual interest, intrinsic-extrinsic motivation, achievement motivation (expectancy, value, etc.), curiosity, and rewarding feeling, all using a sample of schoolchildren. Specifically, the relationship of CIRF with the scales of the Individual Interest *(*Hidi & Renninger, 2006), Motivated Strategies for Learning Questionnaire (Duncan & McKeachie, 2005), Expectancy-Value Model of

Achievement Motivation scale (Eccles et al., 1983), Curiosity and Exploration Inventory-II (Kashdan et al., 2004) and the Sensitivity-to-Reward Subscale (based on Gray's Reinforcement Sensitive Theory; Conner et al., 2018) were examined. As indicated earlier, it was predicted that all of the subscales are positively correlated with CIRF.

4.3.1. Method

4.3.1.1. Participants. A total of 75 (36% female, 54.7% male) participants aged between 13 and 14 years old took part in the study. The participants were recruited in a mixed-sex secondary school in the UK. The survey data were collected by a computer.

With regards to race/ethnicity of the participants, 32% of participants classified themselves as White, 5.3% as Asian or Asian British, 34.7% as Black or Black British, 8% as from multiple ethnic groups, and 9.8% identified as another ethnic group or did not state their race/ethnicity.

4.3.1.2. Materials and procedure. Each participant responded to the CIRF developed in the previous chapter (see Appendix 3). Participants also responded to the questionnaires in this study, which shall be described in detail now.

4.3.1.2.1. Individual Interest. Individual Interest Questionnaire (IIQ) consists of seven items and comprises a single factor (Rotgans, 2015), and focuses on measuring students' inclination and engaging with a school subject positively (e.g., "I always look forward to my Chemistry lessons, because I enjoy them a lot"). The scale considers predicting students' cognitive engagement and on-task behaviour and attitudes, which are boredom, attention, self-efficacy, enjoyment and curiosity (Rotgans, 2015). For this study, Maths was used instead of Chemistry. The scales are assessed on a five-point Likert scale, where 1 = 'Not true at all' and 5 = 'Very true for me'(see Appendix 6).

***4.3.1.2.2. Motivation*.** The Motivated Strategies for Learning Questionnaire includes a self-report instrument consisting of six motivation and nine learning strategies scales with 81

items (Pintrich et al.,1993). For the current study, the intrinsic (four-item) and extrinsic motivation (four-item) subscales were used. The intrinsic motivation subscale focuses on students' perception of why a learning task is chosen or engaged (e.g., "I prefer course material that really challenges me so I can learn new things"). In contrast, the extrinsic motivation items focus on students' goal orientation for grades, rewards, performance, and competition (e.g., "Getting a good grade in this class is the most satisfying thing for me right now"). The scale is scored on a five-point Likert scale, where 1 = 'not at all' and 5 = 'perfectly'(see Appendix 7).

4.3.1.2.3. Curiosity. The Curiosity and Exploration Inventory-II (Kashdan et al., 2009) is based on a two-factor motivation model to seek out knowledge. They are new experiences (*Stretching*: five items) and a willingness to comprise the novelty, uncertainty and unpredictability in daily life (*Embracing*: five items). For example, the stretching subscale has the item "I actively seek as much information as I can in new situations", while the embracing subscale has the item "I prefer jobs that are excitingly unpredictable" (see Appendix 8). The scales are assessed on a five-point Likert scale, where 1 = 'very slightly or not at all' and 5 = 'extremely'.

4.3.1.2.4. Achievement Motives. The Expectancy-Value Model of Achievement Motivation by Eccles et al. (1983) provides a comprehensive framework to understand adolescents' social and academic experiences, values and beliefs, task-specific expectancy and achievement behaviour (Fan, 2011). The scale proposes a model under five subcategories, which are *Ability Beliefs* (three item), *Expectancy* (two items) and *Usefulness* (two items), *Importance* (two items), and *Interest* (two items). The expectancies of students for success are measured by considering how students will deal with upcoming tasks, while ability beliefs refer to the perception of individuals regarding their current competence on a task (Eccles et al., 1993); these are assessed within the domain-specific level rather than specific activities (see Eccles et al., 1983). Motivation and achievement values are defined in different components

of this scale: *attainment value* or *importance* (i.e., the doing well of a current task), *intrinsic value* (i.e., the enjoyment of doing the task), *utility value* or *usefulness* of the task (i.e., how an individual will use it in future plans such as for science degree) and *cost* (i.e., how an individual will engage in one activity such as doing homework). Interest shows some overlap within the constructs of intrinsic and utility value. Although interest is discussed alongside intrinsic motivation in the literature—which an individual enjoys by doing a task—the utility value supports the extrinsic reasons to engage with a task. Therefore, interest can be related to intrinsic and extrinsic motivation. From a theoretical perspective, interest emphasises intrinsic and extrinsic value so that it overlaps with the intrinsic and utility value. The scale focuses on individuals' perceptions of their own previous experiences in terms of social-cognitive variables. Each of the subscales and items is rated on a Likert scale differently (see Appendix 9).

4.3.1.2.5. Rewarding Feeling. The Sensitivity-to-Reward Subscale (10 items) is based on Gray's Reinforcement Sensitive Theory (RFT), which underlays the behavioural activation system, the BIS and the fight-flight system (Conner et al., 2018). These systems are presumed to produce individual differences in learning, motivation and emotion with their perceptions (Cooper & Gomez, 2008). The Sensitivity-to-Reward Subscale measures behaviour approaches in response to reward with trait impulsivity, trait anxiety and aversive stimuli (e.g., "I worry about things that I said or did"). The scale is scored on a four-point Likert scale, where 1 = 'somewhat untrue' and 4 = 'very true'(see Appendix 10).

4.3.2 Results

4.3.2.1. Correlation and reliability. When looking at the scales to measure internal consistency in the table below, the results of Cronbach's alpha indicated mostly good internal consistency of the items for each the scales (the scales ranged from 0.66 to 0.87), but Curiosity-

Embracing (α=0.67), Achievement Motives-Expectancy (α=0.66), and Achievement Motives-Importance (α=0.69) were not sufficiently internally consistent according to the criteria of George and Mallery.

Table 4.4. The Results of Cronbach's Alpha

	N	Item no	α
1.CIRF	66	9	0.84
2.Individual Interest	75	7	0.83
3.Rewarding Feeling	75	10	0.87
4.Motivation Strategies- Intrinsic	75	4	0.74
5.Motivation Strategies- Extrinsic	75	4	0.84
6.Curiosity Stretching	75	5	0.82
7.Curiosity-Embracing	75	5	0.67
8.Achievement Motives- Ability Beliefs	75	3	0.84
9.Achievement Motives- Expectancy	75	2	0.66
10. Achievement Motives - Usefulness	75	2	0.78
11.Achievement Motives-Importance	75	2	0.69
12. Achievement Motives -Interest	75	2	0.85

Table 4.5 shows the means, SDs and intercorrelations of all the measured variables. Correlations between the CIRF and other scales were generally modest-to-high and statistically significant with Curiosity-Embracing *(r*=.50, p<0.01); Achievement Motives-Usefulness (*r*= .37, p=.002), Motivation Strategies-Extrinsic (*r*=.32, p=.008), Individual Interest (*r*=.30, p=.012); Curiosity-Stretching (*r*=.24, p= .044) and Achievement Motives-Importance (*r*=.24, p=.045). Nevertheless, Rewarding Feeling *(r*= .22, p=.066); Motivation Strategies-Intrinsic (*r*=.22, p=.073); Achievement Motives-Ability Beliefs (*r*=.10, p=.422), Achievement Motives-Expectancy (*r*=.02, p=.853) and Achievement Motives-Interest (*r*=.11, p=.342) does not show a significant correlation. Although there is still a positive correlation with the CIRF, these results are inconsistent with the hypothesis.

Table 4.5. Means, SD, and correlations between the scales

	N	Mean	SD	1	2	3	4	5	6	7	8	9
1.CIRF	75	4.66	1.08	*	0.30*	0.22	0.22	0.32**	0.56**	0.50**	0.1	0.02
2.Individual Interest	75	2.59	0.89	0.30*	*	0.31**	0.60**	0.57**	0.51**	0.53**	0.56**	0.58**
3.Rewarding Feeling	75	3.37	0.85	0.22	0.31**	*	0.24*	0.31**	0.44**	0.40**	0.44**	0.22*
4.Motivation Strategies- Intrinsic	75	3.31	0.90	0.22	0.60**	0.24*	*	0.60**	0.31**	0.43**	0.28*	0.30**
5.Motivation Strategies- Extrinsic	75	3.57	1.01	0.32**	0.57**	0.31**	0.60**	*	0.34**	0.35**	0.32**	0.25*
6.Curiosity Stretching	75	3.33	0.91	0.24**	0.51**	0.44**	0.31**	0.34**	*	0.71**	0.30**	0.22
7.Curiosity-Embracing	75	3.22	0.87	0.50**	0.53**	0.40**	0.43**	0.35**	0.71**	*	0.41**	0.28*
8.Achievement Motives- Ability Beliefs	75	4.16	1.34	0.1	0.56**	0.44**	0.28*	0.32**	0.30**	0.41**	*	0.69**
9.Achievement Motives- Expectancy	75	4.65	1.31	0.02	0.58**	0.22*	0.30**	0.25*	0.22	0.28*	0.69**	*
10. Achievement Motives - Usefulness	75	4.26	1.50	0.37**	0.57**	0.33**	0.33**	0.43**	0.36**	0.53**	0.50**	0.57*
11. Achievement Motives-Importance	75	4.54	1.31	0.24*	0.54**	0.32**	0.44**	0.58**	0.29*	0.33**	0.62**	0.54**
12. Achievement Motives -Interest	75	3.86	1.60	0.11	0.67**	0.34**	0.41**	0.35**	0.31**	0.34**	0.60**	0.67**

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

To summarise, CIRF is correlated with other types of curiosity, interest and motivation scales, confirming some convergent evidence for the construct validity in this study. However, Rewarding Feeling, Motivation Strategies-Intrinsic, Achievement Motives-Ability Beliefs, Achievement Motives-Expectancy and Achievement Motives-Interest are inconsistent with expectation.

4.3.2.2. Regression. Regression analysis was used to predict the relation between CIRF from the other scales. The results revealed that Curiosity-Embracing (standardised β=.45, p= 0.002) was a powerful predictor. As for the other predictors, there is no significant association between them and CIRF: for instance, Individual Interest (standardised β=.18, p= 0.33), Curiosity-Stretching (standardised β=.29, p= 0.41) and Achievement Motives-Expectancy (standardised β=-.14, p= 0.45). All the predictors explain 36% of the variance for CIRF. This outcome suggests that Curiosity-Embracing is a relatively strong predictor of how schoolchildren comprise the novelty, uncertainty and unpredictability during knowledge acquisition in CIRF.

4.3.2.3. Confirmatory Factor Analysis. To examine the model fit of the CIRF for this study, the CFA was applied, as was the CFI ≥ .90, TLI ≥ .90 and a RMSEA < 0.08**.** Unlike the previous study, the CFA model did not show a good fit [X_2(27, N =75)=68.41, CFI=.81, TLI=.69, RMSEA=.14], although the factor loadings are all satisfactorily high (see Table 4.6).

Table 4.6. The Results of Confirmatory Factor Analysis for CIRF

Item (N=75)	Factor Loading
It feels pleasant to learn something new	0.57
When learning something, I like thinking about what I will know at the end of it	0.40
I feel rewarded when I understand the things I did not know before	0.66
I enjoy discovering new information	0.63
I expect positive feelings when learning new material	0.46
If there is anything that I do not know, I cannot stop thinking about it	0.74
Getting a new knowledge feels addictive	0.73
I have a strong desire for knowledge	0.77
Whatever I learn, I feel like I crave new knowledge	0.65

To summarise, although CIRF correlated significantly and positively to Curiosity-Embracing, Achievement Motives-Usefulness, Motivation Strategies-Extrinsic, Individual Interest, Curiosity-Stretching and Achievement Motives-Importance. Conversely, Rewarding Feeling, Motivation Strategies-Intrinsic, Achievement Motives-Ability Beliefs, Achievement Motives- Expectancy and Achievement Motives-Interest did not show any significant correlation. However, CIRF was not deemed a good fit for this study, while the factor loadings were still high. It is also worth noting that Curiosity-Embracing showed a high contribution to CIRF.

4.4. Discussion

This section seeks to report the findings of the two studies conducted to test the construct validity of a newly developed Curiosity and Interest as Rewarding Feeling scale (CIRF). The instrument is different from existing instruments in that it explains curiosity and interest in the same framework, with a focus on rewarding feelings in the process account of curiosity and interest. The recent literature of cognitive science in terms of curiosity and interest have recognised the role of reward processing on curiosity and interest (Murayama et al., 2019). The CIRF based on this framework contributes effectively to the current understanding of the sustainable knowledge-acquisition process.

The first Study 3a showed that epistemic curiosity with I-type curiosity and D-type curiosity relates with both CIRF and risk-taking (i.e., Thrill-Seeking); thus, providing evidence of convergent validity. However, D-type curiosity was not consistent with the research expectations. When looking at one item from D-type curiosity (e.g., *"*Difficult conceptual problems can keep me awake all night thinking about solutions") and CIRF (e.g., "If there is anything that I do not know, I cannot stop thinking about it"), the feeling towards knowledge acquisition might make it emotionally taxing to decide whether it is deprivation or reward by considering individual differences. Besides, the risk-taking construct contributed positively to CIRF, which shows the need for challenges during the knowledge-acquisition process (e.g., "The anxiety of doing something new makes me feel excited and alive"). Additionally, these constructs—interest, deprivation, and risk-taking—were associated positively with CIRF, but interest showed a higher contribution on CIRF. These results highlighted other factors (i.e., tolerance for uncertainty, anxiety, expectancy beliefs) between the awareness of a knowledge gap and information-seeking behaviour in the reward-learning model of CIRF.

It is also worth noting that CIRF did not show a good fit with the one-factor model, which is inconsistent with the previous study. One possibility for this discrepancy could be the

relatively low number of participants. Previous studies have demonstrated that a reasonable sample size of at least *N*= 150 is required in such a model as we used in the current study (Kline, 2013). In summary, although the relationship with D-type curiosity is inconsistent with the stated expectation, the findings here support CIRF and the reward-learning model in terms of construct validity Regarding D-type curiosity, knowledge gaps are found to alert people's attention and this change reveals an aversive feeling of deprivation, which is the driving force of people's curious behaviour (Loewenstein, 1994). This issue could be understood as the strong seductive power of curiosity (Lau et al., 2018). The current study's results further demonstrated this critical issue: although the hypotheses were generally supported in terms of the framework and CIRF, the results regarding D-type curiosity require further investigation to better understand the cause behind this positive relationship.

The second study 3b explores the success CIRF has in relating interest, rewarding feeling, motivation (e.g., intrinsic and extrinsic), curiosity (e.g., stretching and embracing), and achievement motives (e.g., ability beliefs, expectancy, usefulness, importance, and interest) constructs on schoolchildren to support the construct validity of CIRF. The results revealed that CIRF was related significantly and positively with Curiosity-Embracing, Achievement Motives-Usefulness, Motivation Strategies-Extrinsic, Individual Interest, Curiosity-Stretching and Achievement Motives-Importance. Yet, Rewarding Feeling, Motivation Strategies-Intrinsic, Achievement Motives-Ability Beliefs, Achievement Motives-Expectancy and Achievement Motives-Interest were not significantly related with CIRF.

The one factor model (see Study 1) was applied for these studies. The CFAs did not show a good model fit, even if the factor loadings are all satisfactorily high. In summary, the findings largely support the construct validity of CIRF, although further studies may want to include greater sample sizes and wider variety of measures to further determined the construct validity of the scale.

5 Chapter 5: General Discussion

5.2 Summary of Findings

In the first study (Chapter 2), we measured participants' naïve beliefs about curiosity and interest by asking how they defined these two concepts in their daily lives. There is still a growing interest in the theory of curiosity and interest in education and psychology (Ainley, 2019; Grossnickle, 2014; Gruber et al., 2014; Kang et al., 2009; Loewenstein, 1994; Murayama, 2018; Renninger & Hidi, 2011; Renninger & Hidi, 2016; Silvia, 2006; Shin & Kim, 2019), although our study is the first to have evaluated people's naïve beliefs regarding the definition, differences, and similarities between curiosity and interest by focusing on their subjective experiences. Using a qualitative method, we observed that curiosity is understood as active feelings towards uncertainty, yet interest with more orientated towards certain things is more stable than curiosity. However, the results also showed substantial overlap between curiosity and interest, especially in terms of the fact that both emphasise the knowledge acquisition process.

To further address the nature of curiosity and interest in terms of a measurement perspective, we developed a new curiosity and interest as rewarding feeling scale in the second study (Chapter 3) based on the framework that considered the knowledge acquisition process in the reward-learning model by Murayama et al. (2019). Specifically, we focused on the rewarding feeling towards the knowledge acquisition process by considering the steps that the process manifests: the awareness of the knowledge gap, the information-seeking behaviour, the knowledge acquisition, the knowledge base, and the moderators (tolerance for uncertainty, anxiety, and expectancy beliefs) in the framework when generating the items. The items are designed by focusing on the rewarding feeling of knowledge acquisition. Results revealed that the Curiosity and Interest as Rewarding Feeling (CIRF) scale has a one-factor structure (the rewarding feeling of the knowledge acquisition), consisting of nine items. While the support for the new scale was demonstrated with adults/schoolchildren and for both genders, we also

found that adults had more rewarding feelings toward knowledge acquisition than schoolchildren in the samples. These findings are consistent with the idea of having a curiosity and interest scale in the same framework based on the rewarding feeling in knowledge acquisition, and encourage the evaluation of the construct validity of the new scale.

In the third study (Chapter 4), we used the newly-developed scale (CIRF) to evaluate the construct validity by correlating it with other theoretically-relevant constructs using samples from schoolchildren. We carried out two studies; Study 3a examined the construct validity's relationship with epistemic curiosity (interest and deprivation) and risk-taking constructs, and, as for Study 3b, individual interest, motivation, curiosity, achievement motives, rewarding feeling, and desire for knowledge were examined. The first study revealed that CIRF is positively related to I-type of curiosity and D-type of curiosity, as well as Thrill-seeking in schoolchildren. Although most of the results were largely consistent the theoretical predictions, the relationship with deprivation type of curiosity was not. Lastly, there was one factor model which did not show a good fit in Study 3a, but the items still had high factor loadings.

In Study 3b, Curiosity-Embracing, Achievement Motives-Usefulness, Motivation Strategies-Extrinsic, Individual Interest, Curiosity-Stretching and Achievement Motives-Importance showed substantial positive correlations with CIRF. These results confirmed the predictions and expanded further for CIRF construct validity. To our knowledge, this is the first study to have examined and developed a scale for curiosity and interest based on the framework focusing on the rewarding feeling of knowledge acquisition (Murayama et al., 2019). The scale did not significantly relate to Rewarding Feeling, Motivation Strategies-Intrinsic, Achievement Motives-Ability Beliefs, Achievement Motives-Expectancy or Achievement Motives-Interest. Besides, the scales scores exhibited mostly adequate internal consistency, although, again, the confirmatory factor analysis did not show a good fit. The

factor loadings were, however, still high. Overall, the two studies (Chapter 4) largely supported the construct validity of CIRF.

Our studies consider the psychological mechanism of curiosity and interest as the basis for evaluating the distinctions between, and overlaps of, curiosity and interest. Besides, the rewarding feeling of knowledge acquisition in the reward-learning model is tested along with the development of CIRF. Our results suggested that showing the differences and similarities of curiosity and interest from people's naïve beliefs does not separate them in their behavioural and psychological process, yet their overlaps on knowledge acquisition, learning process, and motivation sufficiently support the framework. Our studies, therefore, expand upon these findings, and the current thesis suggests support for the model; CIRF demonstrated constructive validity evidence by showing the relation with reward-related feelings such as Achievement Motives-Usefulness and Motivation Strategies-Extrinsic, and the effect of this relation on adults and schoolchildren (Study 3).

5.3 Critical Evaluation

5.3.1 General Strengths

This thesis has provided a critical examination of curiosity and interest in terms of whether or not they are different based on people's naïve beliefs using a qualitative method and the development of a new questionnaire. The findings have implications for the theoretical perspective of the reward-learning model. Specifically, previous research focused on the constructs of curiosity and interest separately (see Introduction). However, describing their process is complex, and all aspects of their concepts are intertwined with one another. The reward-learning framework essentially suggests that curiosity and interest are not separable constructs, in that they are part of the same reward-learning processes of knowledge

acquisition. Hence, we have combined curiosity and interest in our developed scale to understand the rewarding feeling of knowledge acquisition.

5.3.1.1 Study 1

In the first study, we used a qualitative task which involved asking questions regarding the definition of curiosity and interest in the eyes of naïve people. The study successfully showed that curiosity is defined as active feelings (e.g., active thinking, a fleeting feeling, and a child-like emotion) towards uncertainty. However, interest is more stable than curiosity, with the latter more orientated towards certain things (i.e., more intense and sustainable attentional focus and engaging for learning or discovering something). More importantly, the study found that the knowledge acquisition process had an overlap between the terms, and, supportively, they were proven to be essential for learning or acquiring new information by serving as motivation for exploration (Berlyne, 1960; Guba & Lincoln, 1994; Loewenstein, 1994; Silvia, 2006). Thus, the first study's findings add to the ever-expanding field of curiosity and interest research by clarifying the role of reward-learning in thinking about the constructs of curiosity and interest.

Recent accounts of curiosity and interest (Ainley, 2019; Alexander, 2019; Shin & Kim, 2019) highlighted similarities between the in-the-moment reactions to identify both curiosity and interest from knowledge bases. For example, there are two puzzles for students; the first includes a new topic and the other comprises a topic connected to their interest. When students solve the puzzle including a new topic, they actively seek information and their reactions for information are towards novelty or complexity within uncertainty or ambiguity. This information-seeking process of solving the puzzle is considered a manifestation of curiosity (Ainley, 2019 cited in Kid & Hayden, 2015). As for the other puzzle that they are interested in, they examine their previous knowledge and schemas. When their knowledge is not sufficient

for the puzzle reflecting their interest, they will follow the similar knowledge process that we call curiosity for the puzzle including a new topic (Ainley, 2019). This means that the students employ a similar knowledge acquisition process for the new topic and the familiar topic (their curiosity and interest), indicating that curiosity and interest are different in terms of output behaviour but they are still based on the common psychological processes. Our study supported the idea, and might encourage understanding of curiosity and interest by using the same knowledge acquisition process.

5.3.1.2 Study 2

In this study, we developed CIRF and evaluated the scale's construct validity. It is a useful tool with which to measure the rewarding feeling in knowledge acquisition, and Study 3 suggests that the scale supports the best-fitting model with one factor, which is the rewarding feeling of knowledge acquisition. One strength of the scale is that CIRF is a theoretically-driven scale examining curiosity and interest – especially from the theoretical standpoint of reward learning. CIRF emphasised rewarding feeling along with the single factor by showing the reliability of the scale. Therefore, the developed scale is short and straightforward to interpret, making it easy for applied researchers to use when examining people's rewarding feeling of knowledge acquisition. The previous curiosity and interest scales have been developed predominantly based on multidimensional factors (see Section 1.5.1.3). All of the aspects of the previous scales have supported understanding the characteristics of curiosity and interest in people's social life, personality, and education. Yet, it is not clear how researchers choose a scale in actual research, and there has also been confusion between curiosity and interest in terms of conceptualisation, theoretical perspectives, and measurement labels.

We also showed that the scale was applicable to adults/schoolchildren and females/males similarly, but participants demonstrated age differences. Specifically, adults

experienced a slightly more rewarding feeling for knowledge acquisition than kids. The development of curiosity and interest is an underexamined topic that warrants more attention. CIRF reflects the value of knowledge acquisition and the meaning of reward during the knowledge acquisition process between adults and schoolchildren. Adults are likely to have more knowledge than children, and as a result it is likely that adults value knowledge more than children. The value of knowledge as a reward is more likely to be utilised as a capacity to self-boost interest-based engagement over time for adults. Of course, kids also have the same inherent learning process but adults might have more of a knowledge base than kids to follow their interest-based engagement for knowledge. For schoolchildren, the development of curiosity and interest could be more difficult due to the lack of knowledge and limited metacognitive ability to be aware of the knowledge gap. In that respect, there should be an awareness of the differential mechanisms underlying age differences in information-seeking behaviour (Gruber & Fandakova, 2021; Murayama, 2019).

5.3.1.3. Study 3a & Study 3b

In the third study, which comprised two sub- studies (Study 3a and Study 3b), we examined schoolchildren's motivation and learning process with CIRF and the other scales. The first study (Study 3a) suggests that CIRF has construct validity as it is related with *interest*, *deprivation*, and *thrill-seeking*, but its relation with interest is numerically higher than with other constructs. In fact, interest contributed substantially to CIRF in regression analysis. The strong association of interest with CIRF strengthens the underlying curiosity and interest focusing on positive emotions through the reward-learning model. Although *deprivation* is not consistent with our expectation, it is worth mentioning that CIRF originally had a sub-scale focusing on the rewarding feeling related to the knowledge gap – this knowledge gap has been implicated in the triggering of a strong desire to acquire information (Lowenstein, 1994); in

fact, the strong seductive power of curiosity to fill the knowledge gap makes people decide irrationally (Lau et al., 2020; Silvia, 2006). Thus, the association between deprivation-type curiosity and CIRF can be understood from this perspective. In fact, *thrill-seeking* – another aspect of curiosity that leads people to explore novelty, complexity, and uncertainty at the risk of potential negative outcomes or feelings – was also positively related to the proposed scale. Besides, these constructs also clarify one important nature of curiosity: it could induce both positive and negative emotions when learning something new. The reward-learning model could explain these dual aspects by putting forward the comparison of the expected reward value of new information and the rewarding experience to understand both feelings and decisions during the knowledge acquisition process.

For the last study (Study 3b), CIRF was positively and significantly related to motivation, curiosity, and interest scales of similar constructs, but was not related to scales measuring rewarding feeling and the other motivation scales. It was also found that *Curiosity-Embracing* predicted CIRF, while rewarding feeling and interest constructs did not. Yet, *Individual Interest* and *Curiosity-Stretching* had substantially strong correlations. CIRF needs to be tested in a broader community sample to strengthen our expectations, especially for rewarding feeling in the reward-learning model. Moreover, while extrinsic motivation strategies correlated positively with CIRF, intrinsic motivation strategies did not. Some empirical studies support "motivational transformation" from extrinsic to intrinsic rewards (Hashem, 2021; Hayamizu, 1997; Lepper & Greene, 1975; Wiechman & Gurland, 2009; Notz, 1975; Weinstein, 2021). Even if students showed their curiosity and interest towards the rewarding feeling of knowledge acquisition, the achievement motives (i.e., *Ability Beliefs, Expectancy and Interest)* with knowledge acquisition did not show a relation with CIRF. After repeated information seeking, it is possible to develop long-term engagement in information-seeking for a particular domain (Donnellan et al., 2021; Peterson & Hidi, 2019; Savolainen,

2014; Scacco & Muddiman, 2019). This provides more internal sources with which to resolve knowledge gaps and people comprehend new information along with their abilities and accumulating knowledge. The connection between the perceived competence of students after acquiring the knowledge and rewarding feeling of knowledge acquisition might be examined with our framework. The framework highlights the capacity of people to show their self-boost interest-based engagement in time for themselves during the knowledge acquisition process (Murayama, 2019). Along with these results, the motivational transformation process of students could be examined using a more elaborated design.

Study 3a and Study 3b strengthened CIRF and provided a better understanding of the reward-learning model. Moreover, *I-type of curiosity* and *Curiosity-Embracing* suggest that the instrument was sufficiently sensitive to measure curiosity and interest construct over the rewarding feeling of knowledge acquisition. As CIRF was related to the motivation measures in our studies, some achievement motives and motivation strategies of students might be better examined in terms of the rewarding feeling of knowledge acquisition. Moreover, understanding curiosity and interest together during the learning process can allow students to engage in, or maintain, their knowledge acquisition process. We can perhaps put forward how students might autonomously use their curiosity and interest by considering their rewarding feeling of knowledge acquisition in education. Additionally, the reward sense of students and educators might be examined with more research. Overall, this work contributes to existing knowledge of curiosity and interest by providing new insights into how they are related to learning and motivational processes.

5.4. General Limitations

We focused on people's naïve beliefs regarding curiosity and interest and the development of curiosity and interest scale based on the reward-learning model in all three

studies. We conducted a mixed method in order to gain complementarity perspectives on the phenomena of curiosity and interest. While the qualitative method supports the development of a deep understanding of a phenomenon and/or the generation of new theoretical perspectives, the quantitative method makes it possible to confirm studies, such as theory testing (Venkatesh et al., 2013). For this thesis, I combined these methodologies to reach a deep understanding of the concepts. On the other hand, the studies all rely on people's introspective report (subjective report). It is possible that these subjective reports do not consider the real psychological processes. This causes some limitations in terms of methods and instruments, such as generalisability, sample size, and the correlational nature of studies.

In all studies, the data were assessed online using an online platform or participants recruited in a particular event. Online studies allow us to collect a large number of responses, and data quality has been demonstrated in previous studies. For example, recent studies have reported sufficient quality for qualitative data collected online (Gairy et al., 2020; Strickland & Victor, 2020) and the use of online platforms for qualitative and quantitative studies has increased (Houghton, 2014; Gairy et al., 2020; Halls et al., 2018; Kashdan et al., 2020; McLean et al., 2019; Thomas et al., 2017). However, they have certain limitations. For example, it is difficult to obtain more in-depth information from participants; future studies may benefit from semi-structured interviews, which allow follow-up questions and the chance for participants to clarify some phrasing, thus providing an even richer dataset. Semi-structured interviews may also be more appropriate for children, allowing researchers to focus on the child-like forms of curiosity and interest and potential differences from adult forms. Furthermore, the online format may prevent participants from investing deeply in their responses, potentially prompting more shallow-level answers than we were hoping for. In addition, participants' responses in the current study all seemed sensible to the coder.

In addition to such general limitations, Study 1 asked participants for definitions of curiosity and interest, rather than subjective experiences in their daily lives. We decided to ask for definitions to understand how people define curiosity and interest beyond their subjective experiences. Even though, the responses they provided simply reflected their post-hoc (not in-the-moment) explanations of the concepts (Brophy, 2005), we believe that such a post-hoc explanation still provides valuable information about how people understand curiosity and interest in their daily lives. However, future research should examine the validity of our findings with moment-by-moment assessment, e.g., ecological momentary assessment (Tang et al., 2020). Moreover, while Study 1 collected data from a relatively broad range of age groups with different ethnic and educational backgrounds, the study is not designed to provide results that can be generalised to broader populations. For example, the sample did not include children or schoolchildren under 18 years old, and there was also no diversity in nationality to evaluate cultural bias, because the study was conducted online with US citizens only. Beyond the English language, many other languages have distinct words that represent curiosity and interest (e.g., "Neugierde" and "Interesse" in German, "Merak" and "Ilgi" in Turkish, and "Ko-ki-shin" and "Kyo-mi" in Japanese), thus indicating that the distinction is a relatively universal phenomenon. Future studies should examine the generalisability of our findings and potential cultural differences using cross-linguistical comparison.

When developing the new scale, we followed "theoretical analysis" to ensure the content validity of the new scale and to ensure that the items reflected the desired construct validity (Arias et al., 2014). Following this, psychometric analysis was applied to measure construct validity and reliability. During the above process, there were some methodological limitations. For example, the possibility of participant bias, social desirability, and demand characteristics affecting the validity of the findings appeared in the self-reporting methodologies. Another limitation was the potential existence of systematic missing data in

the web-based survey (Morgado et al., 2017). This is likely to have obscured the outcome. For instance, the potential nonresponse bias (i.e., not responding to demographic or attitudinal variables) and coverage bias (i.e., not responding to the survey or not accessing the internet) from participants raises problems in web surveys. In fact, while the newly-developed scale was embedded in the Science Museum Project on an online platform (Study 2), because of the other attractive curiosity and interest games which were available for participants in the project, participants might not have been interested in, or paid profound attention to, CIRF, especially younger participants. The museum environment would have distracted participants' attention. Likewise, Study 3 on schoolchildren had similar limitations, e.g., the class environment and feeling tedious when filling in many online surveys because of their adolescence period (their attention can be distracted easily, Swing et al., 2010) and the fact that they could not read the items well. Therefore, in-person survey or survey interviews should be applied in future research to reduce the concerns about confidentiality and these kinds of biases, even if they are more costly and more time consuming.

5.5 Implications

5.5.1. Curiosity and Interest as Rewarding Feelings

An implication of this thesis is the possibility of considering curiosity and interest as the rewarding feeling of knowledge acquisition in the same framework. Past research has mainly focused on curiosity and interest as separate constructs (e.g., epistemic/perceptual curiosity, and situational/individual interest), regarding interest as part of curiosity (e.g., interest and deprivation type of curiosity) (reviewed in Chapter 1); however, the characterisation of curiosity and interest together in the knowledge acquisition process was also indicated within active/stable feelings and certainty/uncertainty in the thesis. Furthermore, some aspects of curiosity and interest theories have recently been challenged. For instance, the

"wanting" and "liking" processes have been evaluated under the incentive salience system (a reward system), such as the interest and deprivation type of curiosity (Litman, 2005; Shin & Kim, 2019; Murayama et al., 2018). FitzGibbon et al. (2020) suggested that incentive-salience motivates within the seductive lure of curiosity, which refers to seeking information without considering negative consequences. Another recent study indicated that curiosity increases even if increased uncertainty in outcome positively and negatively is perceived about the valence of information (van Lieshout et al., 2021). These results do not directly support the reward-learning model, but still indicate the possibility that the common distinction of curiosity and interest may not be helpful to understand people's information seeking behaviour. Besides, our findings highlighted the overlap of curiosity and interest in terms of their effect on positive emotions, and the *deprivation* construct predicted CIRF. Therefore, rather than thinking about these constructs separately or one within the other (one being related to positive and the other being related to positive emotions), it may be more reasonable to assume that they reflect the same knowledge acquisition process (Donnellan et al., 2021). Therefore, our findings indicate that these aspects of curiosity and interest research should be re-evaluated according to the reward-learning perspective. Our findings should lead to more research focusing on the rewarding feeling in knowledge acquisition without being strongly distracted by the distinction between curiosity and interest.

5.5.2. Triggers of Curiosity and Interest

The triggers of curiosity and interest have been discussed in the literature, especially in the context of state curiosity and situational interest in educational psychology (for a recent review, see Ainley, 2019; Alexander, 2019; Shin & Kim, 2019). In our thesis, people's naïve beliefs have indicated curiosity is triggered by external stimuli, which is followed by the development of interest. Moreover, other research has suggested that triggers for curiosity and

interest are predominantly affected by domain-general topics (for a recent review, see Hidi & Renninger, 2020). Awareness of knowledge gaps resulting from an expanded knowledge base or boosting information seeking for a specific domain can begin with both bottom-up and top-down processes (Donnellan et al., 2021; Gordon, 2019; Howe, 2007). For example, an expanding knowledge base for a specific domain can occur because of environmental stimuli (i.e., bottom-up process) and people can perhaps self-generate their own questions after newly-gained information has been acquired (i.e., top-down process) (Bowler, 2010; Donnellan et al., 2021). Therefore, it is unclear whether the specific triggers for curiosity and interest are from the bottom-up features of saliency or top-down guidance in the knowledge acquisition process. Importantly, the reward-learning framework does not clearly distinguish the triggers between curiosity and interest, because all the triggers of curiosity (or situational interest) are important starting points of the knowledge acquisition process, and its long-term development. That is, regardless of whether A is a trigger for curiosity or interest, A should reflect a knowledge acquisition process, irrespective of whether it comes from bottom-up features, motivational goals, or social environments. Therefore, there is no point in distinguishing the triggers of curiosity and interest in a strict manner.

5.5.3. Motivation and Learning Process in Curiosity and Interest

In this thesis, we generally found that knowledge acquisition is associated with positive types of motivation, confirming that the positive motivational/emotional loop in the knowledge acquisition process. While our studies placed emphasis on motivation and positive emotions during the knowledge acquisition process (van Lieshout et al., 2021), the rewarding feeling of knowledge acquisition as an intrinsic reward is typically conceptualised as a version of reinforcement-learning models (Montague & Berns, 2002; Berridge, 2004). Thus, a positive feedback loop which appears in the knowledge acquisition process is inherently inseparable

from human learning and decision making, indicating the importance of conceptualising motivation and learning in an integrated manner. In fact, it is confirmed that CIRF was positively related to learning constructs in our scale validation study (e.g., motivation strategies-extrinsic, individual interest, curiosity-embracing, and curiosity-stretching) and the cyclic of intrinsic motivation in the reward-learning model. The developed scale generally emphasised motivation and learning altogether. Future studies should consider the role of learning and cognitive processes in our interest-based engagement.

The idea that both curiosity and interest can be understood as essential for the learning process is in line with the literature on both curiosity and interest. Curiosity is defined as serving to motivate exploration and interaction with new information (Guba & Lincoln, 1994; Groves et al., 2021). Likewise, interest is an emotion directed towards knowledge that motivates learning and exploration (Silvia, 2006). Prior reviews have highlighted the role of interest in encouraging people to think deeply and use good meta-cognitive skills (Freud, 1915; Hidi, 2000; Silvia, 2006; Wong et al., 2020). Most studies concerning curiosity have discussed curiosity in relation to overarching themes of information-seeking and gaining knowledge, e.g., epistemic curiosity (Berlyne, 1960), interest-deprivation-type curiosity (Litman, 2008), and state-trait curiosity (Kashdan et al., 2004; Litman & Silvia, 2006). Our results therefore also corroborate existing theories of curiosity, such as those that refer to it as the "cognitive appetite" (Buhler et al., 1928), a "thirst for knowledge" (Freud, 1915) and/or an "appetite for knowledge" (Blumenberg, 1983). Our research is also in line with previous studies that investigated curiosity and interest in terms of willingness to spend cognitive resources on learning new information (Kang et al., 2009) as the main human motivation for learning (Silvia, 2006) and academic performance across different learning environments (Boscolo et al., 2011).

5.5.4. The Distinction of Curiosity and Interest: In Connection with Past Theories

Our findings showed that interest was often considered a form of curiosity and was seen as being stronger than curiosity by lay persons. It was also stronger in terms of the intensity of desire and engaging for learning or discovering something. In previous research, these terms were considered theoretically, empirically, and practically different, yet highly related (Silvia, 2007; Litman & Jimerson, 2004; Grossnickle, 2014; Ainley, 2019). One of the overlapping aspects between curiosity and interest is that curiosity and interest both foster undivided attention and engagement towards new information, which complements findings that interest is thought to narrow attentional scope (Sung & Yih, 2016). Our results suggested that interest could be defined as involving more intense and sustainable attentional focus than curiosity – an idea which is consistent with the perspective that interest is a long-term engagement with specific materials during which people enhance their awareness of the self (Hidi & Renninger, 2019).

Emotion theorists claim that while interest serves long-term developmental goals, curiosity relates to novelty and the possibility of actively broadening experiences (Fredrickson, 1998; Williams et al., 2020). Our findings seem to be consistent with this perspective. While our results indicated that curiosity was an active emotion, interest was defined as a passive, sustained and stable feeling. It is worth noting that some participants considered interest as a "passive" feeling as opposed to the active, transient feelings of curiosity. Based on our findings, we have come to the conclusion that we can interpret the above aspect more as referring to the stability of interest. This is consistent with the previous research demonstrating that interest has a motivational function of maintaining engagement with the environment, which allows us to adapt to new experiences that we experience throughout life. (Williams et al., 2020; Fredrickson, 1998; Silvia, 2007). However, our interpretation is open to further discussion.

Our scale suggests that curiosity and interest are inseparable from extrinsic rewards. The reward-learning framework assumes the generation of extrinsic and intrinsic rewards by knowledge acquisition (Murayama, 2019). These are both processed in the common reward-learning system, and the knowledge acquisition process allows for maintainable and sustainable intrinsic rewards. The framework queries how we regulate our engagement when presenting both types of rewards and how we weigh each type of reward (i.e., the generation of a function to calculate in a single value score). Extrinsic rewards are an important part of knowledge acquisition process, unlike what has been claimed in the previous literature (Deng & Zhang, 2020; Burner, 2020; Sansone & Tang, 2021). That said, it is also worth noting that extrinsic rewards are tangible and show incentive salience, but intrinsic rewards are invisible and we cannot see incentive salience immediately (see Under-appreciation, Murayama, 2019). As such, the existence of strong extrinsic rewards might negatively affect the development of self-generation of intrinsic rewards for knowledge acquisition and interest-base engagement. Besides, this development might also be vulnerable to having salient rewards (Horder, 2015; Murayama, 2019).

5.5.5. The Moderators and the Expected Reward Value of New Information in the Reward-learning Model

Our findings suggest that the rewarding feeling of knowledge acquisition (CIRF) is related positively with motivation strategies (i.e., extrinsic motivation), achievement motives (i.e., importance and usefulness), curiosity, and interest. While this finding supports our framework, it should also be noted that there may be some moderators that change such relationship, such as expectancy beliefs, personality traits, and tolerance for uncertainty. Future studies should consider these moderators to have a comprehensive picture of how our developed scale is related to other constructs.

One potential moderating factor might be age. Our findings revealed that adults aged 18-79 experienced a more rewarding feeling related to knowledge acquisition than did schoolchildren aged 12-18. Because of the developmental psychology process, schoolchildren may be less self-aware than adults when it comes to the emotional valence of information (Chu et al., 2021; Gruber & Fandakova, 2021). Moreover, research has found that the curiosity and interest of school-aged children decreases over time and adults are less curious than children (Ziegler et al., 2015; Spinath & Steinmayr, 2008). Even though children have curiosity and interest in momentary experiences, they might not sustain their information-seeking behaviour into adulthood because of their lack of knowledge base (Liquin & Lombrozo, 2020). Additionally, younger children show their interest through a variety of academic domains, whereas older children focus on fewer domains (Gruber & Fandakova, 2021). We believe that it is important to give more consideration to how education settings could increase rewarding feeling of knowledge acquisition for schoolchildren --- this is a very important task for future studies that aim to have practical implications.

5.5.6. Educational Implications

The findings of this thesis might have important implications for future educational practice. Curiosity and interest interact during the knowledge acquisition process as rewarding feeling towards knowledge acquisition. Therefore, educational settings in motivation should carefully consider how the curiosity and interest of people are sustained or engaged within the knowledge acquisition process. They should also consider the complex nature of information-seeking behaviour, desire to know, attention, expectancy beliefs under curiosity and interest as a rewarding feeling of knowledge acquisition.

The evaluation of curiosity and interest between active/stable feelings and certainty/uncertainty during the knowledge acquisition process presented how people engage

with their curiosity and interest together. As well as being defined differently in terms of their conceptualisations as a consequence of psychological construction, they have strong similarities regarding learning process, motivation, and positive emotions. According to our framework, the co-development of knowledge and subjective competence over time might not be distinguishable in the learning system (Murayama, 2019; Wang & Hayden, 2021). The form of knowledge (i.e., immediate answer, deep knowledge) and our perceived competence skills show themselves as some rewarding experiences. We can observe this process in the development of interest (e.g., competence feedback for skills, effort, and cost) (Hidi & Renninger, 2020). Rather than examining the curiosity and interest of schoolchildren separately, every piece of knowledge should be considered to improve their competence skills. As a result of implementing such a measure, their self-boosting effect can increase positively when they learn something.

Curiosity and interest as rewarding feelings of knowledge acquisition also indicates their strong connection to the concept of flow: Flow can be considered as a strong phenomenological state in interest-based engagement in the framework (Murayama, 2019). When students' skills are too low (which initiates anxiety) or too high (which initiates boredom), their knowledge acquisition process does not cause a state of flow. Thus, along with the nature of curiosity and interest, educators can focus on interest-based engagement by considering students' goals, social context, and flow during the learning process.

Moreover, our scale showed the interesting relationship with motivation and achievement motives. Even though CIRF was related significantly to extrinsic motivation strategies, intrinsic motivation strategies were not. Educators could consider the potential motivational transformation from extrinsic to intrinsic motivation, because our framework advocates that, if a positive feedback loop and the self-boosting effect step in, students can have a constantly rewarding experience from knowledge acquisition by showing sustained

engagement in information-seeking behaviour without extrinsic rewards. Interest-based engagement could be fostered by the engagement based on receiving extrinsic rewards in education. Finally, our results highlight the importance of a more holistic approach to curiosity and interest as rewarding feelings of knowledge acquisition, rather than only focusing on their similarities and differences.

5.6. Conclusion

This thesis contributes to our understanding of curiosity and interest based on the reward-learning model. The three studies provide the evidence for the framework from different perspectives (naïve concepts and scale development). While CIRF attempts to understand curiosity and interest as rewarding experience during knowledge acquisition process, their conceptual similarities and differences do not constitute an impediment to use in our learning system. On the contrary, our studies highlight the usefulness of considering curiosity and interest as rewarding feeling without conceptual separation. Besides, the reinforcement properties of curiosity and interest that we highlighted may have significant implications for educational practice (e.g., the role of extrinsic and intrinsic rewards in education). Future studies could address how educators can use effectively the reward learning model to improve students' learning and motivation.

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Appendix 1

Curiosity and Interest as Rewarding Felling Scale							
	Strongly disagree	**Disagree**	**Slightly disagree**	**Neutral**	**Slightly agree**	**Agree**	**Strongly agree**
1)It feels pleasant to learn something new							
2)If there is anything that I do not know, I cannot stop thinking about it							
3)Getting a new knowledge feels addictive							
4)When learning something, I like thinking about what I will know at the end of it							
5)I have a strong desire for knowledge							
6)I feel rewarded when I understand the things I did not know before							
7)I enjoy discovering new information							
8)Whatever I learn, I feel like I crave new knowledge							
9)I expect positive feelings when learning new material							

Appendix 2

The measurement of curiosity as a feeling of Interest and Deprivation				
	Almost never	**Sometimes**	**Often**	**Almost Always**
1) I enjoy exploring new ideas				
2) I find it fascinating to learn new information				
3) I enjoy learning about subjects that are unfamiliar to me				
4) When I learn something new, would like to find out more about it				
5) I enjoy discussing abstract concepts				
6) Difficult conceptual problems can keep me awake all night thinking about solutions				
7) I can spend hours on a single problem because I just cannot rest without knowing the answer				
8) I feel frustrated if I cannot figure out the solution to a problem, so I work even harder to solve it				
9) I brood for a long time in an attempt to solve some fundamental problem				
10) I work like a fiend at problems that I feel must be solved				

Litman, J. A., & Mussel, P. (2013). Validity of the Interest-and Deprivation-Type Epistemic Curiosity Model in Germany. *Journal of Individual Differences*, *34*(2), 59-68. https://doi.org/10.1027/1614-0001/a000100

Appendix 3

Thrill Seeking (The five dimensional curiosity)							
	Does not describe me at all	**Does not describe me**	**Mostly does not describe me**	**Somewhat describe me**	**Mostly describe me**	**Describe me**	**Completely describe me**
1) The anxiety of doing something new makes me feel excited and alive.							
2) Risk-taking is exciting to me							
3) When I have free time, I want to do things that are a little scary							
4) Creating an adventure as I go is much more appealing than a planned adventure.							
5) I prefer friends who are excitingly unpredictable.							

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Appendix 4

The Individual Interest Questionnaire (IIQ)					
	Not true at all	**Not true for me**	**Neutral**	**True for me**	**Very true for me**
1 I am very interested in math					
2 Outside of school I read a lot about math					
3 I always look forward to my math lessons, because I enjoy them a lot					
4 I am interested in math since I was young					
5 I watch a lot of math related TV programs (e.g., Discovery Channel)					
6 Later in my life I want to pursue a career in engineer or a math- related discipline					
7 When I am reading something about science, or watch something about math on TV, I am fully focused and forget everything around me					

Rotgans, J. I. (2015). Validation Study of a General Subject-matter Interest Measure: The Individual Interest Questionnaire (IIQ). *Health Professions Education*, *1*(1), 67-75. https://doi.org/10.1016/j.hpe.2015.11.009

Appendix 5

The Motivated Strategies for Learning Questionnaire					
	not at all	**to a small degree**	**to some degree**	**to a large degree**	**perfectly**
1.I prefer course material that really challenges me so I can learn new things					
2.I prefer course material that arouses my curiosity, even if it is difficult to learn					
3.The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible					
4.When I have the opportunity in a course, I choose course assignments that I can learn from even if they don't guarantee a good grade					
5.Getting a good grade in this class is the most satisfying thing for me right now					
6.The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade					
7.If I can, I want to get better grades in this class that most of the other students					
8.I want to do well in this class because it is important to show my ability to my family, friends, employer or others					

Pintrich, P. R., Smith, D. A. F., Garcia, T., & Mckeachie, W. J. (1993). Reliability and Predictive Validity of the Motivated Strategies for Learning Questionnaire (Mslq). *Educational and Psychological Measuremen*t, *53*(3), 801-813. https://doi.org/10.1177/0013164493053003024

Appendix 6

Curiosity and Exploration Inventory (CEI-II)					
	Very Slightly or Not At All	**A Little**	**Moderately**	**Quite a Bit**	**Extremely**
1. I actively seek as much information as I can in new situations.					
2. I am the type of person who really enjoys the uncertainty of everyday life.					
3. I am at my best when doing something that is complex or challenging.					
4. Everywhere I go, I am out looking for new things or experiences.					
5. I view challenging situations as an opportunity to grow and learn.					
6. I like to do things that are a little frightening.					
7. I am always looking for experiences that challenge how I think about myself and the world.					
8. I prefer jobs that are excitingly unpredictable.					
9. I frequently seek out opportunities to challenge myself and grow as a person.					
10. I am the kind of person who embraces unfamiliar people, events, and places.					

Kashdan, T. B., Gallagher, M. W., Silvia, P. J., Winterstein, B. P., Breen, W. E., Terhar, D., & Steger, M. F. (2009). The curiosity and exploration inventory—II: development, factor structure, and psychometrics. *Journal of Research in Personality*, *43*, 987–998 doi:10.1016/j.jrp.2009.04.011.

Appendix 7

Expectancy–Value Theory of Achievement Motivation	1	2	3	4	5	6	7
1. How good in math are you?	not at all good very good						Extremely good
2. If you were to list all the students in your class from the worst to the best in n	one of the worst						one of the best
3. Some kids are better in one subject than in another. For example, you might b	a lot worse in math than in other subjects						a lot better in math than in other subjects
Compared to most of your other school subjects, how good are you in math?							
4. How well do you expect to do in math this year?	not at all well						very well
5. How good would you be at learning something new in math?	not at all good						very good
1. Some things that you learn in school help you do things better outside of clas	not at all useful						very useful
For example, learning about plants might help you grow a garden. In general, how useful is what you learn in math?							
2. Compared to most of your other activities, how useful is what you learn in m	not at all useful						very useful
3. For me, being good in math is	not at all important						very important
4. Compared to most of your other activities, how important is it for you to be g	not at all important						very important
5. In general, I find working on math assignments	very boring						very interesting [fun]
6. How much do you like doing math?	not at all						very much

Wigfield, A., & Eccles, J. S. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology, 25*(1), 68-81. https://doi.org/10.1006/ceps.1999.1015

Appendix 8

Sensitivity to Reward Questionnaire					
	Very Untrue	**Somew hat Untrue**	**Neither Untrue nor True**	**Somewhat True**	**Very True**
1.I like being the center of attention at a party or social gathering					
2.When I am in a group, I try to make my opinions the most intelligent or the funniest					
3. I take the opportunity to pick up people I find attractive					
4.The possibility of social advancement moves me to action, even if this involves not playing fair.					
5.I prefer activities that lead to an immediate gain.					
6.I like to compete and do everything I can to win					
7.I do things for quick gains					
8.I like to make a competition out of all of my activities.					
9.I would like to be a socially powerful person					
10.I like displaying my physical abilities even though this may involve danger.					

Conner, B. T., Rahm-Knigge, R. L., & Jenkins, A. L. (2018). Revision and clarification of the sensitivity to punishment sensitivity to reward questionnaire. *Personality and Individual Differences*,*121*,31-40. https://doi.org/10.1016/j.paid.2017.09.016