

Research Article

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Enhancing High-School Students' Interest in Mathematics and Their Understanding of STEM Careers: The Role of the Muhibbah Summer Programme

Mansour Saleh Alabdulaziz 

Abstract

Background/purpose. This study aimed to determine the effect of a learning intervention comprising integrated career-based scenarios on students' interest in mathematics and their understanding of STEM careers. The intervention was created by the Muhibbah Summer Programme (MSP) in the Kingdom of Saudi Arabia. This was a residential summer programme hosted by the Imam Abdulrahman bin Faisal University (IAU). A multi-method approach was employed, consisting of a scenario evaluation using a relevance and interest (SERI) questionnaire and interviews conducted after each session.

Materials/methods. A multi-method approach was employed consisting of a scenario evaluation using a relevance and interest (SERI) questionnaire and interviews conducted after each session. The sample comprised 247 secondary-school students (82 males and 165 females), 25 of whom participated in the interviews. Descriptive statistics were used to analyse the questionnaire data, and content analysis was performed to analyse the interview data.

Results. The results revealed that having the opportunity to actively engage in scientific investigations and interact with experts was an essential prerequisite for career-based scenarios to successfully enhance students' situational interest and understanding of STEM careers. These results have crucial implications for pedagogical practice as they provide valuable information on how to design a career-oriented curriculum that increases both students' interest in mathematics and their understanding of STEM careers.

Conclusion. The characteristics of the scenarios that could potentially trigger students' SI and increase their understanding of STEM careers were as follows. Firstly, adopting a problem-based approach that integrates novel scientific practices to increase active engagement among students; secondly, transferring science concepts to a real-world personally relevant context so that students can identify the links between classroom discussions and genuine workplace environments; and thirdly, allowing students to interact informally with experts in order to integrate the STEM career component.



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1. Introduction

The diminishing interest of students in studying science, technology, engineering, and mathematics (STEM) subjects, as well as pursuing associated careers, continues to be a source of global concern (Organisation for Economic Co-operation and Development [OECD], 2018). For instance, estimates suggest that less than 26% of the overall number of tertiary education graduates in Europe are STEM graduates. This number has not changed for the past ten years, but is deemed insufficient to meet the requirements for science-related personnel (Gago et al., 2005; OECD, 2019). Alongside this, the global community faces several significant challenges, including climate change, public health threats, and the pursuit of sustainable living, all of which necessitate an increase in the supply of STEM labor (European Centre for the Development of Vocational Training [CEDEFOP], 2018). In response, formal policies and reports by governments and business groups in numerous countries have recommended integrating STEM into the school curriculum, motivating young people to undertake STEM education and promoting STEM careers (e.g. Department of Education and Skills, Ireland, 2017; Education Bureau of Government of HKSAR, 2016; European Schoolnet, 2017; Honey et al., 2014; Office of the Chief Scientist, 2014).

In the field of mathematics, Oz and Kloser (2021) found that attitudes towards STEM careers were positively predicted by mathematics disposition. The desire to study mathematics or pursue a related career may be initially sparked by relevant, salient, personally meaningful, or unique experiences, both in and outside of the classroom (Schraw et al., 2001). This can engender emotional changes; for instance, a rise in engagement linked to triggered SI (Hidi & Renninger, 2006; Schunk et al., 2010). When such triggering occurs, it focuses students' attention and increases their persistence in completing a learning task (Ainley et al., 2002), resulting in enhanced learning (Harackiewicz et al., 2008). Thus, the continual triggering of SI ensures its sustained maintenance, as evidenced by maintained attention and persistence, along with the growth of responses that are positive, affective, knowledge-related, and value-related (Linnenbrink-Garcia et al., 2010; Renninger & Su, 2012). As a consequence of this, students' attitudes may also shift. For instance, they may exhibit a growing interest in a particular content domain (Hidi & Renninger, 2006; Habig et al., 2018) and identify opportunities for future learning.

In the Kingdom of Saudi Arabia (KSA), the skills gap has been addressed by King Abdulaziz and his Companions Foundation for Giftedness and Creativity (Mawhiba), a leading institute for giftedness and creativity education, through the creation of enrichment programmes and services aimed at nurturing creativity, giftedness, innovation, and other skills in accordance with national challenges and requirements. Thousands of gifted students enroll in Mawhiba summer programmes (MSP) at various institutions every year to explore the connections between creativity, knowledge, innovation, and personal and social skills.

Because the objectives of such programmes in Saudi Arabia are varied, multiple, and often overlapping, educators and researchers have highlighted the importance of using such objectives to evaluate the calibre of these programmes and assess their reliability and validity concerning the target subject (Alsorour, 2003; King Abdul-Aziz and His Companions Foundation for the Gifted, 2008; Wahba, 2007). The fact that numerous studies have assessed the quality of gifted education in Saudi Arabia is extremely reassuring. Among these studies, a substantial number have examined the methodologies employed to identify gifted students (Albusaif & Aljughaiman, 2020; Aljughaiman, 2010, 2019) and instructors' attitudes regarding these programmes (Aljughaiman et al., 2009). Studies have also examined the quality of training offered to educators (Aljughaiman, 2008, 2012). The efficacy of enrichment programs has also been assessed from numerous different standpoints (Al-Aqil et al., 2019; Aldaoud, 2010; AlQahtani, 2009; Al-Qarni, 2010; Aljughaiman, 2011a, 2011 b,

2011c; Maajini, 2006). Regrettably, research on the effect such programmes have on students' interest in mathematics and understanding of STEM careers in Saudi Arabia is currently scarce.

Based on these findings, and to address the diminishing interest in mathematics and STEM careers among students, the researcher assessed the effect of an instructional intervention specially designed by an MSP on students' interest in mathematics and understanding of STEM careers. To achieve this, two main research questions were addressed:

1. How does the MSP influence students' situational interest in mathematics?
2. How does the MSP influence students' understanding of STEM careers?

2. Theoretical Framework and Literature Review

Derived from Social Cognitive Theory (Bandura, 1986), Social Cognitive Career Theory (SCCT) provides a model for understanding how individuals develop interests and make career-related decisions and actions (Lent et al., 1999). This process is the product of two levels of interaction: (a) between the person and their self-efficacy beliefs, outcome expectations, and personal goals; and (b) between these three core variables and other people and environmental variables (e.g. learning environment) that may obstruct or enable the growth of interests, and hence goal-setting and actions with regard to career choices (Lent et al., 1999).

The MSP-designed instructional intervention that formed the focus of this study appeared to target the second level of interaction posited by SCCT, in that a learning environment oriented towards careers that comprises a group of background contextual affordances might exert a positive impact on the decision-making processes students undertake in relation to their future careers. Thus, the researcher assessed the effect of such background contextual affordances (i.e., career-oriented learning environment) on the learning experiences of students (i.e., the outcome of their interactions with career-based scenarios) through the provision of support in the instructional activities.

It was apparent that the MSP had utilised Renninger and Hidi's definition (2011) of interest as 'a psychological state and a predisposition to re-engage particular disciplinary content over time that develops through the interaction of the person and his or her environment' (p. 170). Therefore, to design the study, the researcher utilised Hidi and Renninger's (2006) four-phase interest development model. These phases are as follows: (A) Triggered SI, a short-term type of interest initiated by environmental stimuli; this is an attentional reaction that enables the development of an individual interest, particularly when the stimuli are repeated (Hidi & Renninger, 2006; Palmer, 2009); (B) Maintained SI, a form of interest that endures over an extended period of time: this is an affective reaction towards a scenario with which the individual initiates forms a meaningful and relevant connection (Hidi, 2001); (C) Emerging individual interest, the development of a more stable, dispositional form of interest; (D) Well-developed individual interest, a psychological state and relatively persistent disposition to continually engage with a specific type of content. Thus, SI is defined as a short-term form of motivation generated by various elements in a particular scenario, resulting in concentrated attention and encompassing both affective and value aspects (Hidi & Renninger, 2006). Triggered SI comprises affect-related components such as expressing enjoyment or excitement, whereas maintained SI comprises both affect- and value-related components that arise as a result of individuals identifying personal relevance or meaningfulness within the scenarios they encounter. The model therefore posits that, firstly, SI is triggered and maintained (phases A and B), a process that then leads to the emergence and development of an individual interest (phases C and D). The duration of each phase varies according to the level of individual and environmental support available.

Based upon this theoretical framework, the MSP chose to focus on SI rather than increasing aspirations, as SI can be adopted to continually nurture students' interest in science and

understanding of STEM careers, whereas raising aspirations is a somewhat sophisticated and dynamic process that is difficult to control in a formal learning setting. The programme therefore sought to immediately trigger SI (Phase A) and then support this through environmental stimuli in the classroom environment that allowed students to make connections and successfully maintain the initial elicitation (Phase B). The MSP sought to facilitate the formation of such connections by utilising a personally relevant context and story content for the instructional activities, the latter of which are described in detail later in this paper.

2.1. Gifted Education in Saudi Arabia

The concept of 'gifted education' first emerged in 1968 when three legal articles emphasising the need to identify gifted students and provide relevant educational programmes were included in education policies in the KSA (Aljughaiman et al., 2016). In 1990, the establishment of a Talent Search Project led to the creation of a general ability scale which codified the Wechsler scale, a behavioural checklist completed by parents and teachers, and self-nomination (Al-Nafi et al., 2000). The development of programmes and services for gifted students began in earnest in 1999 through the establishment of the King Abdulaziz and His Companions Foundation for Giftedness and Creativity (Mawhiba). In the following year, the General Administration for Gifted Education was created in the Ministry of Education. Today, almost 90 centres for the gifted have been established throughout the KSA, distributed between both sexes.

The Ministry of Education has now adopted an expanded definition of a gifted student in the KSA, which is that a gifted student is one who possesses exceptional aptitudes and skills or exhibits a performance superior to their peers in at least one of the areas deemed valuable by society, most notably in the domains of educational achievement, mental excellence, special skills and abilities, as well as creativity and innovation. Such students are identified in accordance with the particular scientific foundations and standards employed for this objective (Aljughaiman et al., 2009). Various types of programmes are available for students selected using the approved tools. These programmes offer enrichment in the form of evening and weekend programmes at gifted centres and pull-out programmes in public education schools. During the summer holidays, enrichment programmes are arranged by a combination of gifted centres, universities, research centres, and leading companies (Aljughaiman, 2010, 2011a). One such programme is Mawhiba- IAU, Mawhiba's first award-winning programme, which is the focus of the current study. This was a residential summer programme hosted by the IAU, a higher education institute situated in the eastern province of Saudi Arabia.

2.2. Students' Interest in Mathematics and Understanding of STEM Careers

Over the past 20 years, mathematics education researchers have sought to identify why students' interest in mathematics, from primary school to tertiary education, has declined (e.g., Bennett et al., 2013; Lykkegaard & Ulriksen, 2019). In a systematic review of 28 studies conducted in the US, Reinhold et al. (2018) aimed to identify the reasons why the number of STEM graduates remains low. Arguing that school factors play a vital role in driving STEM study and career aspirations, the researchers examined the influence of secondary schools on STEM career orientations. The findings revealed that structured support from advisers in exploring careers was lacking, and no in-depth information was provided on particular professional paths, motivating students to 'go for breadth' and select a range of subjects from science, the arts, and humanities, so that they do not limit their options. Furthermore, the researchers found that the STEM orientation of students is likely to be bolstered by STEM teaching that highlights mathematics topics relevant to everyday life, focuses on practical applications, is supplemented with extra-curricular STEM activities, and is more likely to strengthen students' STEM orientation and facilitate connections with practising scientists.

A longitudinal study conducted by Blustein et al. (2013), which aimed to support high-school students in viewing STEM fields as feasible career options, reported similar findings. Having participated in a two-week STEM/Career Development summer program, students were interviewed on two different occasions over an 18-month period. The summer programme was reported to have a positive effect in terms of making mathematics more meaningful to students, enhancing their content knowledge, and increasing their desire to pursue STEM careers.

Focusing on opportunities for career exploration, Kudenko et al. (2017) examined current initiatives aimed at nurturing students' aspirations to pursue STEM careers. The researchers gathered quantitative and qualitative data on 79 school-industry initiatives across 14 EU and EU partner countries. The results indicated that most initiatives were short-term or one-off activities, offering limited discussion about STEM careers and contributions from industry representatives. The teachers involved expressed the view that students could not link school STEM subjects to their daily lives and only a few displayed a strong understanding of STEM careers. The teachers argued that more support was required for using contextual and career information, along with additional opportunities for networking with industry partners. These findings suggest that teachers require additional support in engaging in collaborative school-industry activities.

In a similar vein, the findings of recent studies also highlight the requirement for interventions that provide detailed support for students to enhance their interest in mathematics and develop a more realistic understanding of the nature of STEM careers (van den Hurk et al., 2019). Crucial steps in this regard are to furnish teachers with the educational resources needed to partake in collaborative school-industry activities and nurture students' engagement with role models in STEM fields. Previous research demonstrates that a useful strategy for initiating the development of students' interest in STEM careers is to trigger SI in the classroom (Palmer et al., 2017). Accordingly, researchers have advised incorporating changes into the curriculum and enhancing formal and non-formal educational activities to provide students with stimulating and personally relevant experiences in the domains of school mathematics and technology, underscoring the fundamental importance of collaboration between schools and industries (e.g., Reinhold et al., 2018).

3. Methodology

3.1. Research Approach

To collect the data for this study, a mixed-methods approach was employed. Firstly, questionnaires were used to elicit students' written views on the effect of a learning intervention with integrated career-based scenarios designed by MSP on their interest in mathematics and understanding of STEM careers. Secondly, semi-structured interviews were conducted with selected students to probe their responses in much greater depth. This aligns with the approach advocated by Kendall (2008), who stated that questionnaires can be used to verify patterns within larger populations, whilst qualitative interview data can be used to generate a more comprehensive understanding of the views, opinions, and indeed actions of questionnaire participants. Data were collected from participating students throughout the three-week intervention.

Thus, with a focus on triggering interest and increasing awareness of STEM careers, quantitative data were collected at the end of each session using the Scenario Evaluation with Relevance and Interest (SERI) questionnaire, following which qualitative data were collected through interviews conducted with students regarding the added value of their learning experience. The qualitative data, therefore, supplemented and enhanced the researchers' analysis of the quantitative data. Thus, the study comprised three phases: (a) design and development of the career-based scenarios and teaching-learning sequence by the MSP, along with the creation of evaluation tools; (b) implementation of scenarios in the MSP by the researcher and faculty members at the IAU; and (c) data collection and analysis.

3.2. Design: Problem-Based Learning

The design of the intervention was based on Problem-Based Learning (PBL), a model in which teaching begins with a problem that needs to be solved, actively engaging students in activities and tasks deemed appropriate to their learning environment (Barrows, 1996). Several researchers (e.g., Mawaddah and Anisah, 2015; Untarti, 2015) have stated that mathematical problem-solving abilities encompass the following: identifying the known components, the questions being posed, the adequacy of the required elements, the capacity to devise mathematical models, the skills to select and devise problem-solving strategies, and the ability to explain and verify the accuracy of the proposed solutions. Research suggests that using the PBL, individual interest can be developed through repeated arousal of SI, making this model appropriate for the design of this intervention (Rotgans & Schmidt, 2017). Thus, the PBL approach was incorporated into mathematics teaching units in the form of career-based scenarios, comprising personally relevant content, tasks that stimulate participation, collaborative group work, and engagement with experts in STEM fields.

3.3. Career-Based Scenarios

Career-based scenarios are stories that address socio-scientific issues (e.g., addressing climate change in mathematics education), generating a need to interact with STEM experts. A notable feature of the scenarios in the MSP is that the stories were framed within a context that was personally relevant to students, as they linked to their everyday lives, school, and community (Table A1). For instance, in Session B, the students engaged with the scientific laboratory to understand how it can be used in secondary school mathematics to measure food waste and its associated environmental costs. They then discussed global campaigns aimed at alleviating this issue. This topic was considered personally relevant because it linked to current media discourse around these issues. Another contemporary concern was addressed in Session C – evidence suggesting that air pollution is having a substantial impact on both quality of life and mental health, with most people remaining unaware of these effects. Such activities are important because the curriculum currently does not include career-related goals or interaction with experts from STEM fields; moreover, this type of intervention has not been previously examined in the KSA. Thus, due to their content and the involvement of experts, the incorporation of such scenarios into mathematics teaching units is viewed as innovative in the mathematics curriculum. Furthermore, Christidou (2011) asserts that teachers play an important role in shaping students' views; hence, further research is required to explore this role.

3.4. Sample and Questionnaire

The sample consisted of 247 secondary school students attending the MSP at IAU in 2024. In terms of societal culture and access to mathematics resources outside of school, the students constituted a homogeneous group. The primary objective of the MSP was to increase students' interest in mathematics and understanding of STEM careers, for which career-based scenarios were designed as a pedagogical approach. During the MSP, five interventions using these scenarios were implemented in succession, with sessions delivered over a three-week period to first-, second-, and third-grade secondary school students aged 15 to 17 years (Table A1). For these age groups, the MSP utilised integrated scientific tracks incorporating units linked to disciplines as diverse as biomedical sciences, the renewable energy track, anatomy and physiology, engineering design principles, architecture and creative design, encryption and information security, and a newly developed data science and AI track. Additionally, the skills programme included the 'Challenge Overcoming Bag', the purpose of which was to enhance students' personal abilities in accordance with the Kingdom's Vision 2030, and the 'Ethical Thinking Bag'. To ensure that students derived as much benefit from the MSP as possible, the programme strived to create a degree of competition among students so that they

could demonstrate their willingness to raise their scientific level through the content provided by professors and those with specialist expertise on all tracks.

The initial questionnaire comprised 28 items measuring students' perceptions of scenarios. Using this questionnaire, Kotkas et al. (2017) conducted a small-scale study which led to the identification of six core factors: learning value, vocational value, scenario attributes, career awareness, social value, and like and interest. Prior to conducting a large-scale study, the researchers conducted another comprehensive literature review and constructed a new conceptual framework. They also selected 21 questions relating to three dimensions of relevance: individual, societal, and vocational dimensions, and three characteristics of interest: affect, knowledge, and value; these were in order to assess students' views of the career-based scenarios.

For the current study, a modified version of this questionnaire was used, comprising items relating to the interest domain as conceptualised by Hidi and Renninger (2006), Krapp and Prenzel (2011), and Kang et al. (2019). These were divided as follows: affect (three items), value (four items), and career-related information presented in the scenarios (three items) (Appendix B). Taking into account the nature of the questions and the ages of participants, all items were responded to on a four-point Likert scale ranging from totally disagree to totally agree (Kotkas et al., 2017). Additionally, the instrument contained three open-ended questions which asked students to indicate what they liked best, what they liked least, and the reasons why they did (or did not) find the scenario topic interesting. During the course of the intervention, 236 completed questionnaires were collected. To test the internal consistency of each subscale, Cronbach's alpha was calculated and yielded acceptable values for all sessions (0.9 in Session A, 0.8 in sessions B and C, 0.9 in Session D, and 0.7 in Session E).

The researcher's objective in this study was to immediately trigger SI (Phase A). This is manifested as an attentional reaction that allows for the development of individual interest, particularly when stimuli are repeated (Hidi & Renninger, 2006; Palmer, 2009). To engender an emotional reaction, environmental stimuli were presented in the classroom that enabled students to build a meaningful and relevant connection and successfully maintain the initial elicitation (Phase B). The researcher aimed to establish such a connection using both a personally relevant context and story content for the instructional activities. Triggered SI thus comprised feeling-related components such as enjoyment or excitement, whilst maintained SI comprised both feeling and value-related components that were derived from identifying meaningfulness or personal relevance in the scenario with which they were presented.

3.5. Interview Design

In this phase, the researcher conducted semi-structured interviews with 25 students (these students were selected for interviews because each faculty member had a classroom of students to train, as part of the program, which includes several classrooms. The researcher trained one of these classrooms, which included 25 students; therefore, it is easy to interview these students at any time, using the research questions as a guide. The questions that interviewees were asked were the same as those used in the questionnaire. Using semi-structured interviews, however, also enabled the researcher to ask new questions based on the interviewees' responses (Zhang & Wildemuth, 2009). Thus, rather than simply adhering to a set of fixed questions, deeper insights were obtained into students' interest in and understanding of the careers presented in each scenario (Minichiello et al., 1995). The interviews were conducted no later than ten days after the end of each session and prior to the start of the next unit.

3.6. Data Analysis

To analyse the quantitative data, descriptive statistics (Table 1) were calculated using SPSS to generate central tendency measures (median and mode values) for each item. Centred on the affect and value dimensions, this analysis provided an overview of students' interest in each scenario. Next, data from the open-ended questions and interview transcripts were collated and analyzed using thematic analysis to determine the origins of the development of SI and students' understanding of STEM careers. To ensure the reliability of the analysis, the researcher coded all qualitative data, while a random 20% of the dataset was coded independently by another faculty member. Any discrepancies were then discussed until a consensus was reached (Dodgson, 2019).

To perform a qualitative analysis of the SI data, a coding tool was developed based on the sources of SI identified in previous research. Next, the data were analysed using both deductive and inductive approaches in two separate rounds of coding (Miles & Huberman, 1994; Ravindran, 2019). In the first round, a deductive approach was employed, consisting of the two components of SI —affect and value. This served as an a priori system of coding that aligned with the two main categories. Based on this, six subcategories were created along with fifteen codes. In the second round of coding, an inductive approach was adopted to refine the definitions of the subcategories and codes. During this phase, several new codes were introduced and amalgamated into the existing categories. Thus, seven subcategories and seventeen codes in total were derived from the thematic analysis (Tables 2 and C1).

To supplement the quantitative data on information about jobs, career opportunities, and skills, as well as the future options for choosing a career, an initial analysis of the qualitative data on students' understanding of STEM careers was conducted using established codes. Thus, the analysis was based on the following operational definition: students' familiarity with any career or occupation that necessitates a high degree of knowledge in at least one STEM discipline, with an emphasis on background, responsibilities, and duties, and the particular skills that are required (Blotnick et al., 2018) (Table C2).

Table 1. Scenario Evaluation by Students of the Affect and Value Components of SI and Their Understanding of STEM Careers

Items ^a	Session A		Session B		Session C		Session D		Session E	
	n = 247		n = 247		n = 247		n = 247		n = 236	
	<i>Mdn</i>	<i>Mo</i>	<i>Mdn</i>	<i>Mo</i>	<i>Mdn</i>	<i>Mo</i>	<i>Mdn</i>	<i>Mo</i>	<i>Mdn</i>	<i>Mo</i>
SI/Affect										
The scenario was fun.	3.00	3	3.00	3	4.00	4	3.00	3	3.00	2
I like the format of the scenario.	3.00	3	3.50	3.5	3.00	3.5	3.50	3.5	3.50	4
I find the topic of the scenario interesting. ^b	2.00	2	2.00	2	2.00	2	2.00	2	2.00	2
SI/Value										
The topic has something to do with me.	3.00	3	3.00	3	3.00	3	3.00	3	2.00	2

I find this topic important for me personally.	3.00	3	3.00	2	2.50	3	2.00	2	3.00	3
I find this topic important for learning in the programme.	3.00	3	3.00	4	3.00	3	3.00	3	4.00	4
I find this topic important for society.	3.00	3	4.00	4	4.00	4	3.50	4	4.00	4
Career-related information										
I gained new knowledge about jobs and career opportunities.	3.00	3	4.00	4	4.00	4	3.00	3	3.00	4
I developed an understanding of the skills required for this job.	3.00	3	3.00	3	3.00	3	3.00	3	3.00	2
This job/career might be an option for me.	2.00	1	2.00	2	2.00	2	3.00	3	2.00	2

^a1 = totally disagree to 4 = totally agree. The findings were discussed with respect to the two extremes (median = 2.5). ^b0 = no, 1 = cannot decide, 2 = yes.

4. Results

4.1. Career-Based Scenarios Support Students' Development of SI

The components of interest, 'affect' and 'value', were addressed in the first research question. The affective component concerns students' feelings about the scenario and the teaching-learning sequence. The value component concerns students' evaluation of the scenario and the teaching-learning sequence as important, meaningful, and personally relevant.

Table 1 presents the overall results of the quantitative analysis which reflect students' enjoyment of the learning process in terms of positive feelings about the scenario (mdn $\geq$ 3.00, out of a maximum of 4) and the highest level of interest in the scenario topic (mdn = 2.00, out of a maximum of 2) in all the sessions. With respect to the value component, there was general agreement among students that the scenario topics in all five sessions were important for people to be aware of in general and to learn on the programme (mdn $\geq$ 3.00). Additionally, the topics were perceived as personally relevant in all sessions (mdn $\geq$ 2.50), with the exception of 'about air quality' (mdn = 2.00), which was also judged as not personally important (mdn = 2.00).

4.2. Situational Interest and its Sources

Important insights into the sources of SI were generated through the thematic analysis of written responses to open-ended questions ($n = 247$) and transcribed interviews ($n = 25$). These illuminated what the students liked most and found more interesting, important, and relevant. Based on this analysis, the frequencies of the sources of SI were calculated and classified according to 'affect' and 'value' (see Table 2). The category 'affect' was divided into five subcategories which included twelve codes. The category 'value' was divided into two subcategories, each with five codes. The numbers presented in the table denote the number of times students mentioned these sources in each code, subcategory, and in each category.

Table 2. Affect and Value-Related Sources of SI

Affect	Frequencies	
Novelty	+62	-6
‘Be the expert’ activity	26	
Interaction with expert	19	-3
ICT tools	17	-3
Scientific practices	+41	
Problem-based activities	41	
Interest	+40	-13
Interest in the topic	15	-7
Interest in mathematics in general	10	
Interest in the career	9	-7
Interest in school mathematics	6	
Social relatedness	+19	-2
Group work	13	-2
Division of labour	4	
Self-regulated learning	2	
Complexity	+3	-10
Level of difficulty	3	-8
Total	+165	-28
Value		
Knowledge	+72	0
Learning about mathematics topics	36	
Learning about careers	20	
Learning in general	16	
Relevance	+37	-4
Social/Global relevance	23	
Personal relevance	14	-4
Total	+109	-4

4.3. Affect-Related Sources

As indicated in Table 2, 'affect' (n = 165) exerted a remarkable impact on students' SI. Within this category, 'novelty' (n = 62) was viewed as significantly important (n = 72) in triggering students' interest. The strongest sources of SI were 'be the expert' activity/mission' (n = 26), 'interacting with an expert' (n = 19), and the use of 'ICT tools' (n = 17). This suggests that assuming the role of an expert to successfully undertake a task and using software programmes were viewed as somewhat novel, as they were rarely used as part of the teaching process in classrooms. Evidence to support this comes from the following excerpts from interviews conducted with four different students:

It was fascinating to observe how the expert viewed his classroom in a manner that was substantially different. Like the goalkeeper in football who concentrates on a striker's posture to guess where they will kick, experts responded flexibly to the changes in their classrooms that were the most critical. So, the first time I experienced this feeling, I can only say that it was interesting. (Novelty/Interacting with an expert: Session C; Interview with one of the students)

Oh.... I love it! Indeed, this is the first time I have had this experience. (Novelty/'Be the expert' activity/mission: Session A; Interview with one of the students)

It is intriguing to watch how different areas of mathematics are used in practical ways on a computer. We were presented with particular examples that demonstrated how ideas that seem abstract in nature are an essential element of the computers we use each day. (Novelty/ICT tools: Session E; Interview with one of the students)

For instance, to create realistic 3D objects and characters, you need to use geometry, trigonometry, and linear algebra. Such concepts assist in determining the shapes of objects in virtual environments and the ways in which they move and interact, which was fascinating. (Novelty/ICT tools: Session E; Interview with one of the students)

At this juncture, it is important to highlight the steps that were taken to create a cordial and informal environment during the visits by experts and to avoid positioning them as 'genius scientists'. Prior to the visits, the researcher worked closely with the experts to ensure they would discuss their reasons for pursuing a particular career, their work-life and their everyday routine, as well as any challenges they faced, whilst highlighting the cognitive abilities and skills they developed during their studies and throughout their careers. At the same time, students were guided by their teachers to devise a series of questions about the careers of these experts, as well as their personal lives. They were then prompted by the teachers to ask these questions during the visits. Although one of the most common sources in the novelty subcategory was 'interaction with an expert', two examples of a negative influence on student interest are included in Table 2. These comments are in stark contrast to the wider pattern of findings that emerged from interviews conducted after the session titled 'interesting careers that combine biology and mathematics'. Because links to scientific practices such as lab experiments were absent, two students did not find the experts' visits especially engaging, which appeared to have a negative effect on their level of interest. However, the experimentation that subsequently occurred following the experts' visit renewed their interest, thereby 'providing balance' in this session. Below is an excerpt from the interviews with students:

I believe that although biology and mathematics probably seem to be two entirely different disciplines for most students, I believe we now have a balance. (Interview with one of the students)

Particularly notable here is that students found their engagement in scientific practices to be stimulating, regardless of whether an expert was present. In line with this, the second most frequently reported source of SI was 'scientific practices' (n = 37). The students explained that their interest was increased by problem-based activities such as lab experiments (sessions A & E), poster

design (Session B), and modelling (Session C), as demonstrated in the following excerpt from an interview with another student:

Researcher: What part did you find most interesting?

Student: *As you know, we have two sessions in the morning and afternoon every day (skill training programme and scientific training programme), the most interesting aspect of which was when staff members tried to connect mathematics with STEM careers in the session titled 'connections and applications of mathematics in STEM education'.*

Responses under the subcategory of 'interest' revealed that students were more 'interested in the topic' (n = 15) but less interested 'in mathematics in general' (n = 10). Thus, students' SI was triggered by mathematics topics they viewed as interesting.

That said, only a small number of students found the careers interesting (n = 9) which suggests that presenting careers to students they find unappealing may have a negative impact on their interest in the session as a whole. This is evidenced by the positive and negative reactions of two students in the extracts below, one of which was derived from an interview and the other from the questionnaire:

Indeed, I did not find it interesting because I am not interested in epidemiology. (Interview with one of the students, session C)

Yes.... it is extremely interesting because I will need to pursue a career that combines both biology and mathematics such as bioinformatics, mathematical biology, and population biology, one of which could be an option for me when I am older. (Interview with one of the students, Session C)

Another source of SI was 'social relatedness' (n = 19). In terms of subcategories, 'group work' (n = 13) was the most common source followed by 'division of labour' (n = 4) and 'self-regulated learning' (n = 2). This view is evident in the words of the following student:

They employed a new strategy, the 'pieces of the puzzle approach', which is a deductive reasoning task in which each group member is given a piece of information they need to share with other group members. It is impossible to find a mathematical solution unless everyone contributes. Therefore, an important component of this activity is that the group as a whole takes on 'ownership' of the task, but individuals continue to have a degree of personal responsibility. (Interview with one of the students, Session A)

Especially of note in the above excerpt is that the students found working towards a common objective to be an enjoyable experience. However, the students clearly developed uncomfortable feelings regarding 'task complexity', particularly the 'level of difficulty'. Below is a representative example from a student who completed the questionnaire following the session:

Questionnaire: *I found this scenario extremely difficult and quite boring.* (One of the students)

Conversely, two students in the same session stated that the task was interesting because it was difficult, as demonstrated in the following excerpts from interviews with the two students:

Researcher: What aspect did you like the most?

First student: *I am an adventurous person with an intriguing capacity for trying out difficult tasks, so the puzzle scenario was extremely interesting.*

Second student: *Difficulties are part and parcel of everyday life, and I enjoy doing difficult things. For instance, I like puzzles and games as this gives me the chance to make links between the mathematical concepts, skills, and generalisations you need to solve problems.*

It is important to highlight in the above quotes that difficult tasks may stimulate students and trigger their interest under certain conditions, although further exploration is required with regard to self-efficacy beliefs.

4.4. The Value of Learning and Relevance to Global Issues as Sources of SI

As revealed by the results of the thematic analysis (Table 2), the most common source of SI ($n = 72$) in the category 'value' was 'knowledge'. The students stated that they found 'learning about mathematics topics' ($n = 36$) to be meaningful. This is evidenced in the following extracts from interviews with four students:

Air pollution is known to pose a substantial threat to global public health. This, however, is the first time I had learnt that to study air pollution, you need to have an understanding of mathematical concepts that may be unfamiliar to some students. For students who are finding it difficult to understand the mathematics involved, the scenarios presented in this programme provide an excellent yet fundamental resource that will enable them to catch up with their learning. (Interview with one of the students, Session C)

Previously, I had not been aware of any connection between mathematics and the environment as they seemed like separate fields, but through this programme I learnt that they are interlinked in fundamental ways. Mathematics thus offers the methods and frameworks needed to understand and overcome environmental challenges, leading the way towards a sustainable future. In fact, because I have learnt so much more it has become extremely interesting. For instance, a food waste calculator in mathematics enabled me to measure and analyse the amount of food we waste, shedding light on its financial and environmental effects. Now, I like mathematics even more! (Interview with one of the students, Session B)

Understanding and limiting food waste means that, as well as saving money, you can have a positive effect on the environment. The importance of mathematics in our everyday lives has now become clear to me. Whether you are measuring ingredients or calculating change, mathematics is all around us and can be used in such a wide range of areas, which is extremely useful to know. (Interview with one of the students, Session B)

I am now aware that one of the key reasons as to why students find mathematics difficult is that they do not believe it is relevant to their everyday lives. Having completed this programme, I am now in a position to tell mathematics teachers that they can transform the way students perceive mathematics by showing them how it can be used beneficially in their everyday lives. This can be achieved by linking mathematics problems to real-world situations or engaging students by getting them to participate in hands-on activities which involve solving real-world issues. (Interview with one of the students, Session B)

It is evident from these extracts that students find it interesting to use secondary mathematics to learn how to measure food waste and the associated environmental cost, as well as to develop insights into mathematics and sustainability concepts which relate to air pollutants. In other words, their interest in the subject was positively impacted by engaging in a form of learning they considered meaningful.

Another area students also viewed as interesting and useful was 'Learning about careers' ($n = 20$), either through videos and text-based information or by interacting with experts, as the following excerpts from interviews with two students demonstrate:

It was especially interesting to learn that a dispersion model is basically a computational procedure used to predict pollutant concentrations downwind of a source. (One of the students, Session D)

I found it interesting to learn that existing models are based on knowledge of the terrain (surface roughness, local topography, nearby buildings), emission characteristics (stack exit velocity, plume temperature, stack diameter, etc.), and the state of the atmosphere (wind speed, stability, mixing height, etc.). (One of the students, Session D)

Although the least common source in this subcategory was ‘learning in general’ ($n = 16$), the data nevertheless suggested that learning was valued by the students because it was considered important in a general sense, as the following comments from two students illustrate:

I like learning new knowledge which I think might be useful and interesting, as is the case in these scenarios. (Interview with one of the students, Session C)

If asked, I recommend that everyone should attend this programme because it will show you how to transform just about any information into something you want to learn about. (Interview with one of the students, Session C)

This suggests that learning can still be considered interesting in scenarios where it is not viewed as being personally relevant.

Another aspect that influenced students’ interest was the perceived ‘relevance’ ($n = 37$) of the scenario or elements of the teaching-learning sequence. Surprisingly, ‘personal relevance’ ($n = 14$) was less likely to trigger their interest than ‘social/global relevance’ ($n = 23$), as the following comments show:

Questionnaire: *The topic of the scenario was interesting because it is fascinating and an extremely important global issue.* (One of the students, Session E)

I think that most students find it enjoyable to learn about these topics because they know it is important to have an awareness of national and global environmental issues, the knowledge to scrutinise them and the impacts they have, and to think about ways in which these issues can be addressed. From these scenarios, we learnt that we could approach and analyse environmental issues through the lens of mathematics, which includes using techniques such as data collection, graphing, statistics, and numerical calculations. (Interview with one of the students, session C)

These extracts reveal the interest in and sensitivity towards societal issues expressed by the students. By contrast, personal relevance was associated with students’ own experiences and the degree to which they found the topic of the scenario applicable to themselves.

In summary, the analysis revealed an overall positive impact on students’ SI of integrating career-based scenarios into the mathematics classroom, although certain aspects of the scenarios seemed to have been more critical than others. The quantitative analysis indicated that in all sessions, the students found the topic interesting and important for them to know and to learn and expressed positive feelings about the scenario and the teaching-learning sequence. Supplementing this, the thematic analysis of the qualitative data revealed that with respect to triggering students’ SI, affect-related sources were considered to have a greater impact than value-related sources.

Within the ‘affect’ category, the most common source of SI reported by students was ‘novelty’ in relation to the ‘be the expert’ activity, although they did not always find the ‘interaction with experts’ to be especially engaging (e.g. Session C). Nevertheless, students’ SI was stimulated by ‘scientific practices’, allowing them to re-engage when necessary with the session. Furthermore, there was evidence to suggest that collaborative ‘group work’ also helped to trigger students’ interest, as it fulfilled their desire for social relatedness. Another source of SI was the use of topics students perceived as interesting, which was directly connected to their own personal interests. Finally, both positive and unpleasant feelings were aroused by ‘task complexity’ or a perceived high ‘level of difficulty’, suggesting that students’ interest was impacted by their self-efficacy beliefs.

The most frequently reported source of SI in the 'value' category was 'knowledge', especially 'learning about a mathematics topic', with less importance afforded to 'learning about careers' and 'learning in general'. Although it was not always considered personally relevant, the latter was viewed as useful by the students and therefore interesting. Likewise, students' interest in and sensitivity towards global issues was evidenced by the fact they found 'social/global relevance' more interesting than 'personal relevance'.

4.5. The Link Between Career-Based Scenarios and Understanding of STEM Careers

The analysis of the questionnaire data revealed that with respect to students' understanding of STEM careers, they reported learning information about the STEM jobs presented in the intervention, as well as career opportunities, and developed an enhanced understanding of the skills needed for these occupations ($mdn \geq 3.00$) (Table 1). However, with the exception of becoming a mathematician ($mdn = 3.00$) in Session B, students rejected the careers presented in the intervention as being an option in all the sessions ($mdn = 2.00$). Analysis of the interview data generated more detailed insights into students' views on the knowledge they gained and their future career options.

4.6. 'I Did Not Know What This Job Involved'

The qualitative analysis demonstrated that students viewed themselves as having more knowledge about STEM careers at the end of the intervention than they did at the start. They reported gaining new information about particular jobs and the tasks of experts within those occupations. The following series of excerpts presents representative examples of their views:

I was aware that food waste is a major problem on a global scale, but I was unaware that mathematics could be used to analyse patterns of food waste, forming the basis for improved management and reduction strategies; hence, I know now about the existence of a job in this field that involves important applications of mathematics. (One of the students, Session B)

This extract shows that the student was grateful to be given information about the role mathematics can play in reducing food waste and the scientific practices associated with this. The following excerpt presents another student's views on the work of an acoustic engineer:

Although I knew there would be people who work with sound, I did not know that you need to have an extensive education in mathematics if you want to qualify as an acoustic and sound engineer. I was also unaware that you could get a job teaching mathematics to sound engineers. (One of the students, Session C)

I found this job interesting because on this programme we were visited by engineers whose expertise is in mathematics; furthermore, we asked them questions in order to find out more about their work. It is exciting to think that in the future we will be able to experience what it is like teaching mathematics to students specialising in acoustic engineering. As a result of participating in this programme, mathematics has genuinely become a lot easier. (One of the students, Session C)

Especially notable here is that the student found having an expert in class to be enjoyable and that they could acquire genuine information about the profession simply by asking the expert direct questions. In a similar vein, the following excerpt shows that by engaging directly with an expert, students reshaped their understanding of what it meant to be a civil engineer:

Although I knew what an engineer was, I did not know what a transport civil engineer does. I guessed, but got it a little bit wrong as I thought it was only something to do with engineering, but in fact it has more to do with mathematics. Having listened to the expert, I now understand that a civil engineer draws on mathematical principles to design and develop structures and methods for using materials and the natural forces that surround us to the benefit of all. Because I now know that mathematics is the gateway and key to all sciences, I like it much more now. Previously, I used to

wonder what you would gain from studying mathematics at school, but thanks to this programme I now enjoy mathematics and look forward to helping aspiring civil engineers become proficient in mathematics. (One of the students, Session D)

I thought there would be people who work in the field of civil engineering, but didn't know that mathematics can apply to those with this particular job title. Having the expert in was really enjoyable and I liked the fact that we could ask him questions and find out what it is we needed to know. What he told us was very detailed and I found it really helpful to know that teaching mathematics to civil engineering students who are just starting their studies is a valuable challenge. Most students only have a small amount of knowledge when it comes to understanding what the work of a civil engineer entails, and even though they may be aware that mathematics is vital for their studies, a substantial proportion struggle with basic mathematics. Therefore, I made the decision to help students who work with mathematics at university or any company in which I work. (One of the students, Session C)

To be honest, I was unaware that civil engineers needed to study mathematics, but struggle with it due to the level of the difficulty involved. Therefore, I will pursue a career that allows me to teach these students so that they become leading engineers. (One of the students, Session C)

Such excerpts indicate that students' interest in pursuing particular STEM careers is influenced by the fact their initial understanding of such careers was insufficient or incorrect.

4.7. 'I Enjoy it a Little but do not Want to Pursue it in the Future.'

The analysis revealed that the students were keen to learn career-related information (Table 2). Yet, in line with the descriptive statistics (Table 1), they rarely reported a desire to pursue such careers. This viewpoint is evident in the following extracts:

Being in the sixth grade, I viewed myself as excelling in mathematics, and now, following the positive reinforcement I received on this programme, I will certainly pursue a career as a mathematician or statistician. (Interview with one of the students)

A notable point in the above extract is that having different career aspirations is the primary reason for not wishing to pursue these careers. Indeed, analysis of the qualitative data revealed that just three students stated that they wished to choose one of the careers in the future, as the following quotes illustrate:

I believe that the process of selecting a career from the many options available has become a common and difficult issue in the contemporary work environment, but I am open to considering such career options sometime in the future, and then I will make my final decision. (One of the students, Session D)

I don't know what I want to be, so I will see what happens in the future. (One of the students, Session E)

Of note in the above extracts is that these students have not yet developed a particular career aspiration; hence, they will consider these jobs because they want to 'keep their options open'. The results revealed that students' understanding of STEM careers was increased by the intervention, particularly in the sessions attended by experts (sessions C, D & E). The students described forming a general understanding of the careers presented in terms of the specific expertise, duties, and skills required, knowledge which is primarily sector-specific. In terms of investigating future career opportunities, most students did not find it interesting to learn about careers, and few intended to choose one of these careers in the future. Some declined to pursue these careers simply because they were not personally interested in them. Generally, students viewed the decision to select a career as a major commitment that could not simply be made having received a sequence of lessons,

even though this occurred over a long period of time and differed notably from their usual educational experiences.

5. Discussion

This study aimed to investigate how students' SI and their understanding of STEM careers can be increased through the integration of career-based scenarios designed by the MSP. The results indicated that under certain conditions, career-based scenarios could function as a mechanism for increasing students' SI along with their awareness of STEM careers. Notably, specific elements of the intervention seemed to be more effective than others. These factors are examined in the following sections.

The sources of triggering and sustaining SI reported most often were interactions with experts and having the chance to use scientific tools and related software. These sources were viewed as unique and unusual and enabled students to fully engage in the teaching activities. An SI source was classified as a 'novelty' if the interest was triggered by something new, if they did not know what was going to happen (i.e. suspense), if something unexpected happened (i.e. surprise), or the format of the task had changed (i.e. variety) (Palmer, 2009). To function as a source of interest and motivation, novelty has to be associated with rewards and reward circuitry (Renninger and Hidi, 2022a, 2022b). The data analysis, however, revealed that these interactions did not always function to trigger and/or sustain SI. Rather, students' interest was more likely to be enhanced if these interactions occurred in informal settings and involved conversations that were largely personal and informal. The added value offered by the novelty effect was identified by Silvia and Kashdan (2021) who proposed that novelty can exert positive effects, engender immediate enjoyment and potentially increase students' interest. This raises questions as to whether such effects diminish when the novelty effect is no longer there, the conditions under which SI is generated through such novel activities, and whether this can be sustained throughout the teaching-learning sequence.

In regard to scientific practices, the findings indicated that participating in scientific practices also served to increase students' SI. Indeed, Krajcik and Czerniak (2013) argued that students cannot learn disciplinary content without participating in scientific tasks and actively building their understanding through work and applying their ideas in real-world settings. In this research, the term 'scientific practices' was used to refer to lab experiments, problem-based activities, poster design, and modelling. Notably, such activities appeared to reactivate students' SI in scenarios where it was fading away or had not even been triggered. This is crucial as ongoing triggering of SI results in maintained SI, which is manifested in ongoing attention and persistence and the growth of responses that are positive affective, related to knowledge, and related to value (Linnenbrink-Garcia et al., 2010; Renninger and Su, 2012).

Another crucial finding was that the degree to which the learning setting was deemed interesting (interestingness) could also serve as a source of SI. Schunk et al. (2010) alluded to the interestingness of a setting when describing the features of tasks and texts that successfully trigger interest. In this research, the interestingness of the learning scenario was defined as interest in mathematics as a discipline, the careers presented in the sessions, school mathematics, and the topics of the scenarios. Generally, students found the topics chosen for the scenarios to be reasonably interesting. Because it is impossible to control a general interest in mathematics, interest in school mathematics, the source of SI reported least, could be increased using topics students consider interesting. This is in line with the findings of Habig et al. (2018) who found that students' interest in a task is derived from being interested in the task itself and the content it contains. Moreover, the results indicate that students' interest is not always triggered by allocating them challenging activities. Rather, triggering is reliant on experiences students have identified as sources of beliefs regarding self-efficacy, such experiences being linked to success or failure (Lent et al., 1999).

With respect to the careers presented in the scenarios, it was apparent that students' interest in a given session was more likely to be negatively impacted if they did not perceive such scenarios as personally relevant. This underscores the value of offering a diverse array of scenario features to capture a wider range of students' interests. It was apparent that the MSP had utilised Renninger and Hidi's definition (2011) of interest as 'a psychological state and a predisposition to re-engage particular disciplinary content over time that develops through the interaction of the person and his or her environment' (p. 170). This agrees with the study's theoretical framework is based on Social Cognitive Theory (Bandura, 1986) and Social Cognitive Career Theory (SCCT).

Moving to social relatedness, Students described collaborative group work as being one of the activities they liked the most in the sessions. Indeed, triggering and even maintaining students' SI was facilitated by such group work. This aligns with previous research indicating that working in small groups increases social relatedness as it enhances a sense of belonging and may, therefore, sustain SI (Hidi and Renninger, 2006; Palmer, 2009).

In regard to learning with relevance, the value-related source of SI reported most often was learning. The findings revealed that the students valued learning about global socio-scientific issues and careers and that this could arouse their interest. This could be attributed to the fact that the ability to transfer science concepts to a real-world personally relevant context allowed students to make valuable associations between theory and practice. This supports Palmer's (2009) identification of learning as a source of SI and further corroborates Stuckey et al.'s (2013) assertion that this occurs when the learning process is deemed to be personally important.

Finally, in terms of developing understanding of STEM careers, because STEM careers are not especially prominent in the school curriculum, this study sought to elicit students' views on whether a learning intervention comprising integrated career-based scenarios designed by MSP would enhance their interest in mathematics and their understanding of STEM careers. The ultimate objective was to increase students' awareness of the opportunities available in the STEM field by forging links between theory, practice, and careers in mathematics classes. The results indicate that this objective had been attained, particularly in sessions where students were given the chance to engage with expert(s) as part of their project work. Specifically, the results revealed that students developed a detailed understanding of the background, skills, and tasks of each of the experts, particularly with regard to the mathematics concepts presented in each scenario. Given such findings, it is evident that career-related information can be introduced in a productive way in mathematics classes as mathematics is a core component of most STEM careers. Therefore, students' interest in STEM careers is likely to be driven by their interest in mathematics. This aligns with the findings of Oz and Kloser (2021) who reported that attitudes towards STEM careers positively predicted mathematics disposition. Moreover, in a large number of countries, formal policies and reports by governments and business groups have sought to integrate STEM into the school curriculum, motivate young people to participate in STEM education and promote STEM careers (e.g. Department of Education and Skills, Ireland, 2017; Education Bureau of Government of HKSAR, 2016; European Schoolnet, 2017; Honey et al., 2014; Office of the Chief Scientist, 2014).

Despite this, the results also indicated that delivering career-related information alone, even if this was done in a manner that was personally relevant and meaningful, did not increase students' interest in delving into the possibility of pursuing STEM careers. This could be explained by the fact that influences on career aspirations cannot be observed within the duration of a student's school career – a longer time interval is required. A more compelling explanation is that developing career aspirations is a complicated process and can largely be predicted by students' self-concept which is deemed to be generally stable by the ages of 15 to 17 (Rüschepöhler and Markic, 2019). Thus, to have a substantive effect on students' career aspirations, more gradual interventions need to be designed that commence at an earlier stage in school life, provide detailed information on STEM

careers and link to the core factors that form students' self-concept such as family mathematics capital, role models, human relatedness, and individualised learning opportunities.

6. Implications and Recommendations

Regarding the implications of this classroom-based study in terms of research (non-formal learning experiences), future investigations should therefore seek to determine the effect on students' career aspirations of long-term career-oriented instruction that begin in primary school and continue through to the end of secondary education.

Continuing this longitudinal approach, it would also be useful to further examine the paths taken by students from secondary school up to entry into the job market. The findings of studies that consider the full spectrum of school life from primary through to tertiary education will comprehensively illuminate the evolving relationship between students' self-concepts and the career choices they make. This will be especially valuable regarding informing recommendations for curriculum design in learning scenarios, as this could enhance the degree to which students identify with mathematics.

Additionally, there would be considerable merit in examining the role teachers play in this process, as Christidou (2011) asserts that teachers exert a significant influence on the views of students. Accordingly, teacher professional development could productively strive to enhance teachers' understanding of the diversity in STEM careers and the array of choices available, and how to integrate these into teaching practices. Research could therefore usefully address the following questions: How do teachers interact with career-based scenarios? How do teachers use career-based scenarios to form links between theory and authentic work? In what ways can teachers be supported to increase students' participation in learning activities oriented towards careers?

Lastly, to furnish planners and decision makers with the information, they are required to make appropriate decisions about programmes; such programmes must be subjected to a process of scrutiny. This will disclose the degree to which programme objectives have been attained, the ways in which they have been achieved, and the barriers that limit progress towards the objectives. As such, programme scrutiny will serve as a central component in the process of developing any programme, establishing whether it should be supported, modified or even terminated. Indeed, because the objectives of summer enrichment programmes in Saudi Arabia are varied, numerous, and often overlapping, educators and researchers have underscored the need to translate such objectives into measures that can be employed to assess programme quality, along with their reliability and validity regarding the target subject (Alsorour, 2003; King Abdul-Aziz and His Companions Foundation for the Gifted, 2008; Wahba, 2007).

7. Limitations of the Research

Despite its evident strengths, this study has a number of limitations that need to be addressed. Firstly, it focused only on non-formal learning experiences, and hence overlooked other factors that may influence students' interest in science and STEM fields. Secondly, the study only considered the MSP at IAU in the east of Saudi Arabia. This limits the degree to which the findings can be generalised across the rest of the country. Nevertheless, this city was a suitable place in which to undertake the research as it has a large population drawn from various areas of the KSA. This was evident in the distribution of participants, who came from the middle of the KSA, the western part, the north-western part, and the south-western region. Finally, the sample comprised high-school students only, as staff were excluded due to the difficulties that would have arisen in obtaining approval to administer the survey to a wider population.

8. Conclusion

This research provided empirical evidence from the MSP on how students' interest in mathematics and their understanding of STEM careers can be increased by integrating career-oriented scenarios into mathematics classrooms. The characteristics of the scenarios that could potentially trigger students' SI and increase their understanding of STEM careers were as follows. Firstly, adopting a problem-based approach that integrates novel scientific practices to increase active engagement among students; secondly, transferring science concepts to a real-world personally relevant context so that students can identify the links between classroom discussions and genuine workplace environments; and thirdly, allowing students to interact informally with experts in order to integrate the STEM career component.

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