



Research Article

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The Reality of the Application of Biology Teachers to Design Thinking in Their Teaching at The Secondary Stage

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Abstract

This study aimed to identify the level of application of design thinking by biology teachers at the secondary level and determine the degree of obstacles they face during its application. The descriptive survey method was used to meet the objectives of the study. The open questionnaire was conducted among a sample of 276 male and female teachers who were chosen by stratified random sampling. 132 male and 144 female secondary school biology teachers were selected as a sample for this study. Biology teachers were chosen using a stratified random method in Riyadh. The collected data has been processed statistically using SPSS version 25. The results showed that the level of application of design thinking was low with an arithmetic average of 2.26, while the obstacles to the application of design thinking were high with an arithmetic average of 3.70. The results also revealed that there are statistically significant differences (0.01) between the average levels of the application of design thinking in favor of teachers. Moreover, there are statistically significant differences (0.01) between the average degrees of obstacles in its application in favor of teachers.

Keywords: biology teaching, design thinking, education, secondary stage

1. Introduction

Science is one of the most basic and important subjects in educational systems in terms of building a scientific culture among learners. Biology, as one of the leading subjects in the natural sciences, is crucial in developing a scientific culture among learners during all stages of education. It is an appropriate medium for linking scientific knowledge to the lives of learners and through which scientific methods can be used in teaching-learning situations. It contributes to preparing learners to adapt and coexist with the living world around them, understand its natural phenomena, identify its problems, and try to solve them.

Biology, as a subject, includes information, facts, experiences, and concepts centered around human beings and their environment and how they interact with the environment and its living and non-living components. Abu Awwad (2015) highlights the importance of presenting this subject to learners effectively and teaching it by solving problems, unlike traditional teaching based on memorization and indoctrination.

A new concept known as design thinking has emerged recently. It is based on innovative and creative solutions to problems. It is one of the terms that many educational institutions consider necessary to apply in schools and employ in a variety of curricula and teaching methods (Hassan, 2016). Design thinking is seen as transforming theory into practice in a competitive environment that is rich in activities, giving up current ideas in exchange for more quality ideas, and practicing different ways of dealing with ideas during their generation or implementation (Kateb, 2014).

The concept of design thinking refers to a creative analytical process that allows learners to innovate, present initial designs, get feedback, and then modify those designs (Razzouk & Shute, 2012). Deventala et al. (2017) believe that design thinking is a process and a creative mechanism for solving problems and creating opportunities to understand people and develop innovative solutions to meet their needs. It is referred to as a human-centered design approach. Dam and Siang (2018) consider it a systematic method that provides an innovative approach to solving complex problems by understanding human needs, reframing the problem in a human-dependent manner, creating multiple ideas to solve this problem, providing an initial design for the best of these solutions, testing, and modifying it in light of the views of its beneficiaries.

Design thinking is a multi-use research method that originated in the field of product design in the United States of America at Stanford University in the seventies and searches for solutions to problems and challenges in a variety of areas such as products, services, or experiences, including the field of education (Val et al., 2017). Integrating design thinking into education is an approach to solving problems that require creative solutions, the ability to synthesize knowledge from a variety of sources, the use of prototypes and simulations, and the making of diagrams and graphs.

In addition, these tools provide alternative paths to experiential learning. It serves as a basis for the accumulation of tacit knowledge, and in this way, it can help bring about the discovery of new knowledge or a pattern of thinking. The essence of the design thinking process lies in the transformation from the idea of design and the production process to a method based on experiment, observation, listening, and practical application to identify the problem and then solve it (Cahen, 2008).

Design thinking focuses on a set of skills that distinguish it from other types of thinking, including emphasizing integrative thinking in understanding scientific concepts. It looks at events in a holistic, non-fragmented manner, learning the skills of cooperation and effective communication with others, thinking about problem-solving using probabilistic logic instead of inductive and deductive logic, and practicing practical application while making and testing models that prepare learners for the reality of their future work efficiently and effectively (Dunne & Martin, 2006).

Many educational institutions have been interested in this kind of thinking, including the efforts of Stanford University, which established the School of Design and was interested in introducing the design thinking model to the educational learning process at all levels. This was supported by the Henry Ford Learning Institute (HFLI), where Stanford University provided many training programs to teachers about activating this model in the classroom and published guidelines and illustrations to develop and refine the skills of learners and teachers in design thinking alike, calling on educators to adopt the design thinking model and realize its merits and stages. (Shively et al., 2018)

Design thinking includes some stages and steps like defining the problem, understanding the visions of others, and ending up with its implementation (Deventala et al., 2017). The process of determining the stages and steps of design thinking has attracted the attention of many researchers and educational institutions.

Many researchers have identified three basic stages of the design thinking process: the stage of inspiration (reaching an important idea), the stage of ideas (presenting a conception of the idea), and the stage of implementation (visualization application in reality) (Brown, 2008). Carrol et al. (2010) presented six stages of the design thinking process, which are: understanding the problem, observing reality, determining the point of view, producing ideas, producing the prototype of the product, and testing and modifying the model to become its final form. They emphasized the importance of

feedback in all its stages.

Likewise, Scheer et al. (2017) defined the design thinking processes as understanding, observation, composition, idea generation, prototype creation, testing, and iteration. At the level of educational institutions, the School of Design (d.school, 2016) identified five steps for design thinking: empathy, identification, idea generation, modeling, and testing, while IDEO

(2019) identified the stages of design thinking for teachers as follows: discovery, interpretation, visualization, experimentation, and development.

Manchanda (2016) indicates that the stages and steps of design thinking are not only linear but take place in a more flexible, practical, and iterative way. For example, more than one stage can be conducted simultaneously by different groups within the team.

Edwald et al. (2019) are of the opinion that teachers' practice of the processes and stages related to design thinking contributes to directing the focus towards educational needs in the learning environment, employing critical thinking to identify problem-solving, practicing divergent thinking, and self-evaluating to reach problem-solving in creative ways, supporting participation and communication among the team. They are also of the view that those practices urge the teacher to build prototypes and express innovative products that meet the needs of learners and encourage them to practice design thinking processes on their own and invest their imagination and creative abilities to solve their academic problems and obtain a product through prototyping, visualization, and thinking outside the box.

Dunne and Martin (2006) also indicate that design thinking contributes to creating a classroom environment rich in stimuli characterized by innovation, enhancing thinking skills, and improving learners' performance through the consolidation of scientific concepts, building a scientific methodology for creative and critical thinking, and providing them with the designer's style.

The use of design thinking in educational environments has remained the focus of many research studies. Kwek (2011) argued that teachers do not have a negative tendency to use the design thinking method, and the mastery of specialized academic knowledge is one of the most prominent teachers' motives for using design thinking in schools. Further, Cupps (2014) found that art and design students follow primitive procedures for design thinking and problem-solving methods.

Like Kwek, Retna (2016) also found that teachers realize the importance of design thinking and that the adoption of design thinking as a teaching strategy enhances students' abilities to solve problems, develops their creative skills, and develops the skill of empathy with others and with the community. He also highlighted some of the challenges that teachers face in the application of this concept. Those challenges include insufficient resources, time constraints, and the difficulty of adopting a new approach to learning and teaching.

Harris (2017) believes that the most important challenges that teachers face when integrating design thinking into teaching are due to two main factors: time constraints and a lack of administrative support for them. This study confirmed that these factors do not reduce the efficiency of the thinking strategy. Crane (2018) also showed that there are deficiencies in the use of assistive technology in facilitating learning and exchanging knowledge related to design thinking in teaching students from kindergarten to twelfth grade.

Painter's (2018) study also revealed that middle school mathematics teachers who have experience of 3 years or less focus on the use of design thinking and have a passion for it because they have seen positive results on learners in increasing the practice of communication, cooperation, critical thinking, creativity, and connecting learning with the real world. The teachers also found that employing design thinking in mathematics classes helps learners master mathematical concepts.

Rizk's (2018) study confirmed the positive impact of a strategy based on the design thinking approach in teaching mathematics on the self-efficacy of middle school students. In a similar manner, the study of Noel (2018) found that the design thinking strategy supports the student-centered learning approach and increases the spirit of cooperative work among students. It also enhances the learning of scientific knowledge among students and contributes to the development of critical awareness and critical thinking.

Tu et al. (2018) also found that design thinking contributes to improving teaching through the participation of learners in the empathy stage, deepening their discussions on design-related topics, and creating an interactive atmosphere for education that enhances the positive interaction between the learner and the teacher. It also increases the learners' interest in the learning process and raises their motivation for self-learning.

The result of Abdel-Aal and Fouad's (2019) study proposed and showed the effectiveness of a science-based approach to design thinking in developing health awareness and life skills among learners. Further, Al-Zubaidi and Bani Khalaf (2020) revealed the positive impact of a science-based educational unit on design thinking and the degree of acquisition of physical concepts.

Based on the scientific interest in design thinking in the educational field and the importance of employing it in teaching, the current study aimed to reveal the importance of the application of design thinking for biology teachers in their teaching. The study also highlighted the biology teachers' practice level of design thinking and the obstacles they face during its application. This study is significant as it contributes to providing the necessary data for future studies in this field.

2. Statement of the Problem

Organizing and building the content of the biology curriculum for secondary education in the Kingdom of Saudi Arabia encourages the learners to build and arrange ideas and practice those scientific ideas in a way that enhances the principles of the Kingdom's 2030 Vision. As the Ministry of Education (2021) says, "We learn to work," so the teachers should provide multiple opportunities to the learners for practicing scientific inquiry. Further, the content should also include many investigative activities that can be implemented during the study of the content, including data analysis laboratories, problem-solving, rapid practical experiments, etc.

The biology curriculum requires the teacher to apply investigation in educational situations, and this is one of the basic aspects recommended by the American National Research Council (2012). According to the American National Research Council (2012), the framework of scientific education from kindergarten to grade 12 includes eight practices: asking questions (for science), defining problems (for engineering), developing and using models, building and carrying out investigations (inquiries), analyzing and interpreting data, using mathematics and computational thinking, building explanations (in science), designing solutions (in engineering), engaging in the scholarly debate based on evidence, accessing, evaluating, and communicating information.

The American National Research Council (NRC), in collaboration with some educational institutions, has also developed the Next Generation Science Standards (NGSS). The Next Generation Science Standards represent a shift in education and learning science; they emphasize the necessity of integrating engineering and the basic ideas of engineering design and technology applications in science education and learning (Moore et al., 2015).

The Next Generation Science Standards highlight the importance of engineering design along with investigation and research. It educates learners by presenting realistic problems that need practical solutions to overcome them (Brenda, 2020). Val et al. (2017) indicate that design thinking is one of the types of thinking that is closely related to engineering design.

Rizk (2018) emphasized the importance of spreading awareness of the concept of design thinking as it can be employed in education. Further, it is an effective tool for improving the learning environment and the level of learners.

One of the recommendations of the World Innovation Summit for Education (2017) was to make great and united efforts to motivate teachers towards achieving excellence in the application of design thinking at all levels of pre-university education. The Summit also emphasized including design thinking as an approach and practice for teaching innovative approaches to solving problems and continuing to conduct quantitative and qualitative research to identify the successful aspects, the reasons for that success, and its relationship to the application of design thinking.

Crane (2018) suggested that there should be some training for teachers about how to use design

thinking in the teaching process. Likewise, Kwek (2011) recommended exploring how design thinking is used by teachers and educational institutions. This prompted the researcher to conduct an exploratory study. 11 biology teachers who taught the first semester of the academic year 2021-2022 in the city of Riyadh were selected as a sample for the study. The questionnaire was used as a tool for the study. This exploratory study showed the following results:

- Three teachers provided a definition that explains the concept of design thinking, and this represents 27.27% of the study sample.
- Two teachers stated that they can apply the stages of design thinking during teaching, and this represents 18.18% of the study sample.
- No teacher indicated that s/he had any previous experience using design thinking during teaching.
- All the teachers indicated that there was a need for training in the field of design thinking.

The scientific interest in design thinking, the recommendations of previous studies, the results of the exploratory study, and the review of previous studies indicate a research gap. So, the present study is an attempt to fill this gap. It seeks to identify the level of application of design thinking by biology teachers in their teaching at the secondary level.

3. Research Questions

The present study seeks to answer the following main question:

- What is the reality of biology teachers' application of design thinking in their teaching at the secondary stage?

The following questions are derived from the main question:

- (1) What is the level of application of biology teachers to design thinking in their teaching at the secondary stage?
- (2) What are the obstacles that biology teachers face when they apply design thinking?

4. Significance of the Study

The present research is of theoretical importance as it provides scientific content about the importance of design thinking and highlights the teaching practices that support the application of design thinking. It also emphasizes the importance of the application of design thinking for secondary-level biology teachers. The present research further explores and addresses the obstacles that limit the application of design thinking in teaching. It suggests that there should be some professional growth programs for in-service biology teachers, with a special focus on the application of design thinking. Moreover, it also presents a tool that can be used to further study this field.

5. Limitations of the Study

The limitations of the current study are as follows:

- (1) Objective limits: The study was limited to revealing the reality of the design thinking application by biology teachers in their teaching for the secondary stage only. The design for teachers is as follows: discovery, interpretation, visualization, experimentation, and development when building the study tool.
- (2) Spatial limits: The data was collected from the secondary school biology teachers in Riyadh.
- (3) Temporal limits: The study was conducted during the second semester of the academic year (2021-2022).

6. Definition of the Key Terms

6.1 Design Thinking

Roterberg (2018) defines design thinking as "a comprehensive innovative approach directed towards solving problems through the generation and development of creative ideas and models to solve them".

The researcher defines procedural design thinking as an innovative approach through which biology teachers in secondary schools in Riyadh practice some operations that aim to solve problems through discovery, interpretation, visualization, experimentation, and development. It is measured by the degree they obtain with the tool prepared for that.

7. Methodology

The study used the descriptive-survey method, which aimed to describe certain phenomena, events, or things. The study sought to identify the reality of the application of design thinking by biology teachers in their secondary school teaching and the obstacles that they faced during its application. It collected facts, information, and observations about them. It also described and defined their circumstances and reported on their status.

7.1 The Sample of the Study

The population of the study consisted of 427 biology teachers, 198 male and 229 female, from secondary schools in the city of Riyadh. The sample of the study, according to the table of Kergcie & Morgan (1970), consisted of 276 male and female teachers who were chosen by stratified random methods. 132 male and 144 female secondary school biology teachers were selected as a sample for this study. Table 1 shows the sample distribution according to the gender variable.

Table 1: Distribution of the sample according to the gender variable

Variable	Variable Levels	Number	Percentage	Total
Gender	Male teacher	132	47.83%	100%
	Female teacher	144	52.17%	

7.2 Research Tools

To seek an answer to the questions of the study and achieve its objectives, a questionnaire was designed that aimed to identify the reality of the application of design thinking by biology teachers in their teaching at the secondary stage and the obstacles to the application of design thinking. Based on previous studies in this field, the researcher designed and prepared the questionnaire. To study the psychometric properties of the tool, the researcher followed some steps:

1. Verification of the apparent validity of the tool: To verify the apparent validity of the questionnaire, it was presented to some specialists in science education. The purpose was to benefit from their opinions about the clarity of the items, the accuracy of its formulation, its importance, its relevance to the topic of research, and the extent to which each item is related to its domain. The tool was modified according to the notes which were agreed upon by 80% or more.

The questionnaire, in its final form, consisted of two dimensions: the level of teachers' application of design thinking and the obstacles that biology teachers face during their application of design thinking. The level of application included the following domains: discovery, 4 items; interpretation, 5 items; perception, 4 items; experiment, 5 items; and development, 4 items. The

obstacles included the following topics: 4 administrative obstacles, 6 obstacles related to the teacher, 4 obstacles related to the learner, and 5 obstacles related to the curriculum. The degree of response to the questionnaire items was graded on a quintuple scale (very high, high, medium, low, very low), and to judge the total degree of practices or obstacles or the degree of sub-domains and their expressions, the arbitration criterion, shown in Table 2, was used:

Table 2: Arbitration Criteria for the application-level of design thinking and obstacles that limit its application

Arithmetic mean value	Application-level and obstacles
From 1 to less than 1.80	Very low
From 1.80 to less than 2.60	Low
From 2.60 to less than 3.40	Medium
From 3.40 to less than 4.20	High
From 4.20 to 5	Very high

Internal consistency and stability of the tool: The questionnaires were distributed to a random sample of 30 male and female biology teachers outside the study sample with the aim of verifying the internal consistency of the questionnaire. The Pearson correlation coefficient was calculated to verify the internal consistency of the questionnaire. It was calculated between the degree of each item and the domain to which it belongs, as well as between the degree of each domain and the total degree of each dimension of the questionnaire to which the domain belongs. The results of the internal consistency of the questionnaire items and their domains are shown in Table 3.

Table 3: The internal consistency of the questionnaire items and their domains using Pearson's coefficient

Questionnaire Dimensions	Domains of each Dimension	The correlation coefficient of each item degree with the total degree of its domains					The correlation coefficient of each domain degree with the total degree of the dimension		
		Item no.	1	2	3	4			
The level of application of design thinking	Discovery	Item no.						0.82**	
		The correlation coefficient	0.72**	0.75**	0.86**	0.65**			
	Interpretation	Item no.	5	6	7	8	9	0.87**	
		The correlation coefficient	0.83**	0.90**	0.90**	0.88**	0.81**		
	Visualization	Item no.	10	11	12	13		0.91**	
		The correlation coefficient	0.87**	0.84**	0.89**	0.91**			
	Experimentation	Item no.	14	15	16	17	18	0.94**	
		The correlation coefficient	0.94**	0.93**	0.88**	0.91**	0.81**		
	Development	Item no.	19	20	21	22		0.88**	
		The correlation coefficient	0.95**	0.94**	0.97**	0.97**			
Obstacles to applying design thinking	Administrative Obstacles	Item no.	23	24	25	26		0.82**	
		The correlation coefficient	0.71**	0.82**	0.71**	0.82**			
	Obstacles related to the teacher	Item no.	27	28	29	30	31	32	0.84**
		The correlation coefficient	0.81**	0.83**	0.87**	0.73**	0.76**	0.50**	
	Obstacles related to the learner	Item no.	33	34	35	36		0.85**	
		The correlation coefficient	0.89**	0.94**	0.90**	0.89**			
	Obstacles related to the curriculum	Item no.	37	38	39	40	41	0.87**	
		The correlation coefficient	0.77**	0.88**	0.90**	0.89**	0.82**		

(**) means statistically significant at a level of (0.01) (*) means statistically significant at a level of (0.05)

It is clear from Table 3 that the Pearson correlation coefficients between the degree of each item and the total degree of the domain to which the item belongs are all statistically significant at the level of

significance (0.01), which indicates that all items are consistent with the domain.

It is also clear that the Pearson correlation coefficients between the degree of each domain and the total degree of the dimension to which the domain belongs are all statistically significant at the level of significance (0.01), which indicates that the degree of each domain is consistent with the total degree of the dimension to which the domain belongs.

7.3 Stability of the Questionnaire

Cronbach's alpha coefficient was used to ensure the stability of the questionnaire. Table 4 shows the results.

Table 4: The stability of the study's questionnaire using Cronbach's alpha coefficient

Questionnaire Dimensions	Domains of each Dimension	Cronbach's alpha coefficient of each domain	The whole Cronbach's alpha coefficient of the dimensions
The level of application of design thinking	Discovery	0.73	0.97
	Interpretation	0.92	
	Visualization	0.89	
	Experimentation	0.94	
	Development	0.97	
Obstacles to applying design thinking	Administrative Obstacles	0.76	0.94
	Obstacles related to the teacher	0.84	
	Obstacles related to the learner	0.92	
	Obstacles related to the curriculum	0.91	

Table 4 indicates that the value of the stability coefficient of the two dimensions of the questionnaire is equal to 0.97 for the dimension of the design thinking application level and 0.94 for the dimension of obstacles to the application of design thinking which are appropriate and reassuring values for the use of the questionnaire.

7.4 Procedures

A letter of approval from Prince Sattam bin Abdulaziz University in Al-Kharj and the General Administration of Education in Riyadh was obtained for the administration of the questionnaire. It was administered after ensuring its validity and internal consistency. It was distributed to a study sample taken from the second semester of the academic year 2021–2022. After data collection and retrieval, the Statistical Package for Social Sciences (SPSS) was applied to analyze and process the data to obtain results.

8. Results

8.1 The Results of the First Question

After collecting the data, the arithmetic mean and standard deviation of the total scores for the application of design thinking and sub-domains were calculated. The results of question 1, "What is the application level of biology teachers' design thinking in their teaching at the secondary stage?" are shown in Table 5.

Table 5: Arithmetic mean and standard deviation of the design thinking application (N=276)

No.	Domain	Rank	Arithmetic mean	Standard deviation	The application degree of design thinking
1	Discovery	1	2.50	0.96	Low
2	Interpretation	2	2.30	0.88	Low
3	Visualization	5	2.13	0.74	Low
4	Experimentation	3	2.19	0.79	Low
5	Development	4	2.15	0.65	Low
The total degree of the application level of biology teachers of design thinking			2.26	0.71	Low

Table 5 shows that the application level of design thinking by biology teachers, with an arithmetic mean of 2.26, is low. The "discovery" domain, with an arithmetic mean of 2.50, appeared in the first rank, and it also has a low degree, while the "interpretation" domain, with an arithmetic mean of 2.30 and a low degree, came in second. In the third rank, the "experimentation" domain, with an arithmetic mean of 2.19, appeared at a low degree. The "development" domain, with an arithmetic mean of 2.15, showed a low score and appeared in the fourth rank, while the "perception" domain, with an arithmetic mean of 2.13, came in the last rank and appeared at a low degree.

The first hypothesis of the study, which states that "there are no statistically significant differences between the application level of design thinking by biology teachers due to the gender variable," was tested to find the statistical differences between the male and female teachers' estimates of the application level of design thinking. The t-test was also used. The results are shown in Table 6.

Table 6: Results of the t-test to indicate the differences between the level of teachers' application of design thinking (n = 276)

Gender	N.	Arithmetic mean	Standard deviation	Freedom degree	T	Significance
Male teachers	132	2.40	0.69	274	3.29	0.01
Female teachers	144	2.12	0.71			

Table 6 indicates that the "T" value is equal to 3.29 that is statistically significant at the level of 0.01. It also shows that there are statistically significant differences at the level of 0.01 between the average application-level design thinking of biology teachers.

8.2 The Results of the Second Question

The results of question 2, "What are the obstacles that biology teachers face when they apply design thinking?" are shown in Table 7. To answer this question, 276 male and female teachers of the biology course in secondary schools in Riyadh were surveyed. After data collection, the arithmetic mean and standard deviation of the total degree of the obstacles faced by biology teachers during the application of design thinking and sub-domains were calculated. Table 7 shows the results:

Table 7: Arithmetic averages and standard deviations of the obstacles to applying design thinking (n = 276)

No.	Domain	Rank	Arithmetic mean	Standard deviation	The application obstacles of design thinking
1	Administrative Obstacles	3	3.67	0.83	high
2	Obstacles related to the teacher	2	3.68	0.82	high
3	Obstacles related to the learner	4	3.65	0.93	high
4	Obstacles related to the curriculum	1	3.82	0.82	high
The total degree of the application obstacles of design thinking			3.70	0.71	high

The results in Table 7 indicate that the average of the obstacles related to the design thinking application by biology teachers, with an arithmetic average of 3.70, is high. The "obstacles related to the curriculum" domain, with an arithmetic average of 3.82, appeared in the first rank. They also show a high degree, while the "obstacles related to the teacher" domain, with an arithmetic average of 3.68, is also high and came in the second rank. In the third rank, with an arithmetic average of 3.67, the "administrative obstacles" domain appeared with a high degree. Further, with a high degree, the "obstacles related to the learner", with an arithmetic average of 3.65, came in the last rank.

So far as studying the statistical differences between the ideas of male and female teachers about the obstacles to the application of design thinking, there are no statistically significant differences between the degree of obstacles to the application of design thinking by biology teachers due to the type of variable. The t-test was used after verification. The results are shown in Table 8.

Table 8: T-test results for the significance of the differences between the application obstacles of design thinking (n = 276)

Gender	N.	Arithmetic mean	Standard deviation	Freedom degree	T	Significance
Male teachers	132	3.86	0.57	274	3.52	0.01
Female teachers	144	3.56	0.79			

Table 8 shows that the "t" value is equal to 3.52, which is statistically significant at the level of 0.01. It indicates that there are statistically significant differences in the average degree of obstacles to the application of design thinking between male and female biology teachers.

9. Discussion

The results of this study show a low level of application of design thinking by biology teachers in their teaching practices at the secondary stage. It indicates that biology teachers do not care about teaching practices that support the application of design thinking. The results also show that the application level of all design thinking skills appeared to be low, with a close to low level of visualization skills, thus indicating the weak interest of male and female teachers in creative solutions to the problems. They adopt and practice regular models to solve the problem instead of creative models.

The results of the study are consistent with the results of Cupps' (2014) study, which also shows that art and design students follow primitive procedures for design thinking and problem-solving methods. The results of the current study also agree with the results of Crane's (2018) study, which showed some shortcomings in the use of assistive technology in facilitating learning and exchanging knowledge related to design thinking in the education of students from kindergarten to grade 12.

The results of the current study differ from those of Painter's (2018) study, which showed that teachers focus on the use of design thinking and have a passion for it because of the positive results. Here it is worth mentioning that all the members of the sample in Painter's (2018) study have experience of almost 3 years in using design thinking. Thus, it can be said that the experience gained from professional development programs is one of the motives for applying design thinking during teaching. Moreover, mastery of specialized knowledge is also one of the most prominent motives for applying design thinking. Likewise, Kwek's (2011) study indicates that teachers do not have a negative tendency to use design thinking and that mastery of specialized academic knowledge is one of the most prominent motives for teachers to use this type of thinking in schools.

The results of the current study also differ from the results of Retna's (2016) study, which found that teachers understand the importance of design thinking and that adopting design thinking as a teaching strategy enhances students' abilities to solve problems and develops their creative skills.

The foregoing discussion indicates that the reasons for the low application level of design thinking may be due to the following:

- Less experience of male and female biology teachers in using design thinking during teaching
- The low level of specialized knowledge mastery among male and female biology teachers
- Biology teachers' lack of awareness of the importance of using design thinking in teaching and its positive impact on learners' learning aspects.
- The misperceptions of biology teachers towards design thinking
- Biology teachers' negative attitudes towards creative problem-solving methods

The results of the present study also show that biology teachers show a high degree of obstacle in the application of design thinking, thus indicating that teachers are aware of these obstacles and may lose the desire and passion to apply design thinking during teaching. The results also show that obstacles related to the curriculum appear to be the highest in rank among other obstacles.

It indicates that the elements of the biology curriculum may not contribute to motivating teachers and encouraging them to apply design thinking in their teaching practices. This is due to environmental problems, the absence of an applied guide to solving problems according to design thinking, the lack of free educational activities related to the reality of learners, the lack of techniques and tools supporting the application of design thinking, and the focus of the biology curriculum on evaluating the cognitive aspect of learners.

This result is consistent with the result of Retna's (2016) study, which shows that there are some challenges that teachers face when applying design thinking, like insufficient resources, time constraints, and the difficulty of adopting a new approach to learning and teaching instead of the traditional approach.

The findings are consistent with the result of a study conducted by Harris (2017), which also shows that the most important challenges that teachers face when integrating design thinking into teaching are due to two main factors: time constraints and the lack of administrative support for them. The main reason for a high degree of obstacles to the application of design thinking may be due to the lack of interest in this style and the treatment of obstacles and difficulties on the part of those who are in charge of education. It may limit its application and the creation of supportive ways to integrate it into education.

It was confirmed by Deventala (2017) in the report of the World Innovation Conference for Education that although the interest in the use of design thinking in the educational environment from kindergarten to the twelfth grade has grown dramatically in the past two decades, it has not given enough importance to design thinking as an essential component of the professional tools among teachers, providing only minimal guidance on how to support design thinking in education and professional development and the guidelines and best practices needed to successfully implement this approach.

The results of the study also show that there are statistically significant differences at the level of 0.01 between the average level of application of design thinking by biology teachers. This indicates that male biology teachers support the application of design thinking in their teaching practices more than female biology teachers.

The results also show that there are statistically significant differences at the level of 0.01 between the average degrees of obstacles to the application of biology teachers to design thinking. This means that male biology teachers are more aware of the obstacles that limit the application of design thinking in their teaching practices than female biology teachers. The reason for this difference may be the different professional preparation programs offered to biology teachers. It can also be said that the professional growth and development programs provided to biology teachers during the service should include some of the activities in the field of design thinking.

10. Conclusion

In conclusion, this study aimed to identify the level of application and challenges biology instructors at the secondary level have when incorporating design thinking into their lesson plans. The data were

processed using SPSS version 25 for thorough analysis utilizing the descriptive survey method and an open questionnaire given to a sample of 276 male and female teachers.

With an average score of 2.26, the study found that teachers who were polled applied design thinking in a rather limited way. Along with this, there are challenging obstacles that have an overall rating of 3.70. In favor of the teachers, statistically significant differences were discovered in both the application and the difficulties experienced.

This study underlines the significance of incorporating innovation and creative models, particularly design thinking, into teaching approaches, particularly within the natural science areas, in light of the findings. It promotes the development of a strategic plan that centers on design thinking and is shared among various educational departments.

Furthermore, given the significance of professional growth and development, this study suggests the creation and ongoing improvement of programs geared at biology instructors, with a particular emphasis on improving their perspectives, teaching abilities, and attitudes toward design thinking. It also recommends the creation of a thorough handbook with instructions for teachers on how to successfully incorporate design thinking into their teaching practices.

In conclusion, this study highlights the potential advantages of using design thinking to encourage imagination and innovation in science teaching. It is up to those in charge of educating future generations to take note of these findings and put the suggested solutions into practice in order to increase teaching efficiency and promote student learning.

11. Recommendations

The study recommends that to integrate models of innovation and creativity in teaching, especially natural science subjects, the in-charge of education should build a long-term strategic plan with a special emphasis on design thinking. It should also be generalized to other education departments and followed up for its implementation in schools. The study also recommends that keeping in view the models of innovation and creativity with a focus on the design thinking model, the professional growth programs for biology teachers should be developed and updated. They should also be provided with in-service professional growth programs to improve their beliefs, teaching skills, and attitude towards design thinking. Further, the study recommends that a teaching guide should be designed that can guide teachers about how to use design thinking in their teaching practices.

12. Direction of Future Research

We recommend studying the reality of the application of design thinking by teachers of natural sciences subjects or other subjects in teaching at the secondary level or in other educational stages. Further research needs to be conducted on the beliefs and attitudes of biology teachers towards design thinking. It is also suggested that there is a need to build a professional growth program based on design thinking and studying its effectiveness in developing the creative teaching skills of biology teachers. Further, after studying the impacts of design thinking on students' problem-solving skills and other variables, a teaching model based on design thinking should be planned.

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