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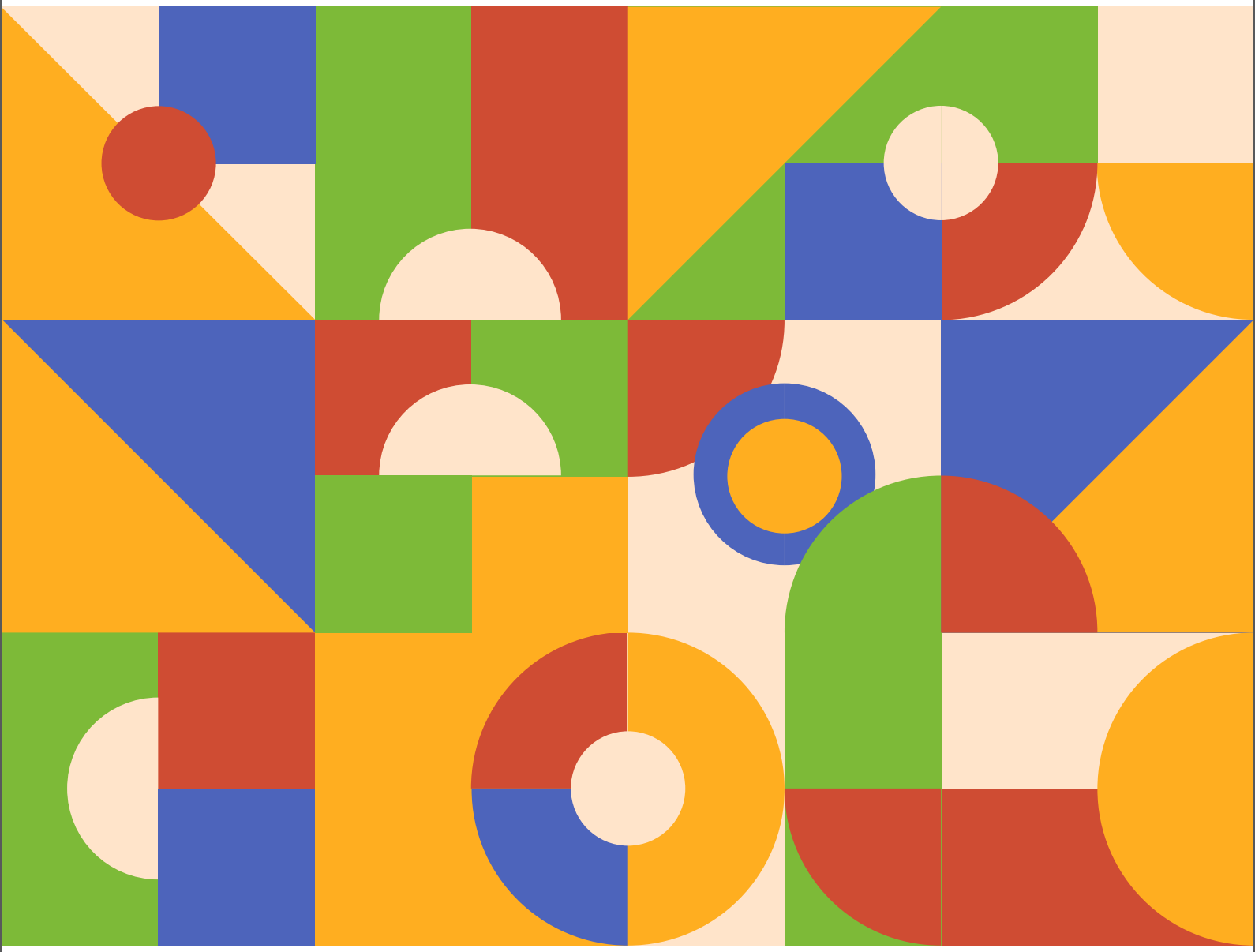

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Interwoven, Navrachana University's peer reviewed interdisciplinary journal, weaves together a wide range of ideas to offer a layered mosaic of scholarly work. Peer reviewed journals are essential for academic work as they bring new rigor to make corrections and also a completely new perspective to the proposed idea.

Interwoven offers a platform to present scholarly articles that are disciplinary and non-disciplinary, and engage in a rich academic discourse. Non-disciplinary articles, because of their generalistic content provide a means for all readers to find a common ground to connect and get involved regardless of their expertise. Disciplinary work, on the other hand, is presented in a form that non-disciplinary readers can read, understand and participate in an academic discourse to reflect, reinvent and expand traditional disciplinary boundaries.

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Interwoven is a double blind peer reviewed interdisciplinary journal of Navrachana University, published online biannually. The journal covers inherently general topics as well as specialized topics written for readers from wide backgrounds. The effort is to build a strong interdisciplinary academic and research culture in the society.

Regarding review process, there is a strong criteria established for an article to be considered for revision, acceptance or rejection. Every article undergoes check for Plagiarism. Each article is reviewed by three referees.

Interwoven has been granted an e-ISSN number (2581-9275). We strongly encourage faculty, scientists, postdoctoral fellows and research scholars to contribute their scholarly work in the form of research articles, review articles, perspectives, critiques, book reviews and articles in social research. We look forward to expand our authors and readers network and set a benchmark in the process of growth for students, faculty, University and the society at large by spreading awareness about various knowledge domains. We also encourage undergraduate and postgraduate students involved in dissertation work to write journal articles and promote new research ideas to expand their vision beyond standard academic curriculum.

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A Perspective on Geometric Pedagogy for Secondary School Students in a Virtual Classroom

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Abstract

We were encouraged to write this article after observing closely a group of students in standard IX, taking the online lessons in Geometry, due to the closure of schools in the Covid-19 pandemic. It was evident from their body language that the diligent efforts of the teacher were not sufficient to grab their attention. Diving deeper, we found that the topics in Geometry involved construction, which relied heavily on explaining the steps by doing them physically in the classroom. To address this and similar issues, we have proposed a pedagogy with an objective to create an interactive environment in virtual geometry classes, where the mathematical concepts and the steps of construction are taught with the traditional methods blended with modern graphic software tools.

Keywords

Geometry, pedagogy, interactive environment

Introduction

Presently many schools across the world are closed as a precautionary measure against the spread of Covid-19 pandemic. The age-old method of classroom teaching has been subsequently shifted to online education, which is a new way of teaching-learning for the instructors as well as the students. Many school children are seriously affected by this sudden shift, whereas their instructors are struggling to find innovative methods of engaging them as

effectively as in classroom teaching. But, as we all know that online education is imposing serious challenges at various levels of teaching-learning, a few of them being discussed below:

- Online teaching requires development of innovative teaching strategies and techniques. Instructors need to be tech savvy to promptly shift to online mode of teaching from the traditional classroom education.
- It is challenging for any subject instructor to grab the attention of students on the computer screen and also to keep them actively engaged for the entire duration of these virtual classes. Also, different courses require different levels of engagements, and hence teaching needs to be customized as per the requirements of the subject.
- Considering the emotional state of students is also very important in online teaching, particularly during such unprecedented times, when many families are in distress due to economic, health and other issues. Children are also affected seriously due to the prolonged lockdowns and pandemic related effects on their families.
- Identifying the slow learners and giving individual attention to students who need extra help may be difficult in virtual classrooms.

Although most of the issues discussed above have evolved as effects of the ongoing pandemic and are difficult to address, but they also provide food for the thought of coming up with innovative ideas at various social, economic, or educational platforms for future use. From our perspective, the present situation also encourages us to modify our age-old methods of teaching to be blended with modern software tools, giving more freedom for experimentation to the students. Playing around with the ideas and learning by exploring is far more engaging than accepting the textbook concepts as absolute truth, as is expected in traditional classroom teachings.

In this manuscript, we present our perspective on the method of teaching geometrical concepts to secondary school students in online mode. Geometry is a science which encompasses a collection of abstract statements and proofs of these statements[1]. Studies in Geometry constitute an inexhaustible source of ideas for developing logical and creative thinking[2]. Practical problems ranging from designing a city, measuring the earth to using shadows to tell time, led to the development of this branch of mathematics[3]. Secondary school students need to have a wide variation of foundational knowledge in Geometry as the building blocks for their respective fields of choice in future. They require a more personalized approach to learn

topics like Practical Geometry, which is a blend of abstract mathematical ideas and their applications to the real world. We closely analyzed the methodologies used by teachers to deliver the topics in the areas of practical mathematics and concluded that it was really difficult to deliver both the problem-solving techniques and the abstract mathematical concepts simultaneously, particularly in online mode. In this regard, we tried to develop a blended approach to make the teaching of practical mathematics in virtual environments more effective, which can also be carried forward in regular classroom teaching later.

Drawbacks in online teaching

- As instructors are teaching remotely, necessary infrastructure like blackboards are usually not present or are difficult to install. They have to depend more on verbal communication instead of figures/graphs/drawings etc. to enhance the learning. Although power point presentations have replaced the blackboard usage, but it has been observed that it allows passive learning in students and a majority of them end up with reduced attention span in the lecture.
- 3D software for giving real time perspective of geometrical shapes is not shown or linked with the mathematical ideas. Incorporating such software requires time and training for the instructor, hence is not an easy task for them.
- There is no eye contact between instructor and student, because of the virtual classrooms. As a result, it becomes impossible to judge the engagement of the students during the class hours. The disengaged students start inappropriate usage of the electronic gadgets.

First, we discuss some preliminary suggestions which are expected to bring interactive and exploratory learning in virtual classrooms, also appropriate for teaching subjects other than mathematics.

Primary Suggestions: These suggestions can be implemented in the virtual classrooms of mathematics and can be modified as per the requirements of teaching other subjects to ensure a conducive environment for learning.

Assumption: Classroom session is of 40 minutes; Maximum classroom strength is 40.

- Putting students together in groups of 6 to 7 students enhances collaborative efforts and creates good interactive learning environment. The assignments can be designed in such a way that students need to interact with each other for solving. They are benefitted by the peer effect of learning and multiple ways of problem solving. This also makes students feel that they are not isolated in a virtual environment.
- Letting one of the groups present the contents of the previous lecture in the first few minutes of the class and giving some time to the other students to raise questions. This reinforces their learning and increases their alertness in class.
- Leading students through real world examples in mathematics and creating attractive visual effects by using different colors for different sets of parallel lines, angles or shapes gives more clarity. Integrating each lesson with short videos on topics like construction of angles or quadrilateral help the students to move along and continue the construction activity. Instructors may share these videos with students through e-mail for their later reference.
- Dynamic geometry software tools allow for exploration in geometric studies. For example, a teacher can ask students to explore how a particular quadrilateral behaves when one of its vertices is dragged and this question is one that cannot be posed in a paper-pencil environment[4]. In fact, playing around with the dimensions, rotation, magnification, etc. of the shapes and figures are possible while using these software tools, which is very important in conceptual understanding of the subject.

Some of the free and easily available software tools to teach Geometry are Geo Gebra, Geometry pad, Shapes 3D, Desmos etc. Instructors need to download and install these software tools from the internet on their computers or smart phones.

We give the following sample problem containing construction work. We also give screenshots which demonstrate the geometrical construction work using Desmos software geometry tool. This software tool is great for teaching geometry and offers a graphing calculator that can be used by students. It allows the instructors to monitor and share student work. It is even accessible for visually impaired students.

This Sample Problem is selected from the topic ‘Number Systems’ whose solution contains geometrical construction work. The abstractness of the dense packing of rational and irrational numbers in the real number system is very difficult to visualize, particularly for a student who

has just begin to learn mathematics as a concept rather than a tool to manipulate real world observations. Constructing the beautiful spiral of circles with irrational numbers as radii and their intersection with the real line gives the idea that the irrational numbers are densely packed within the real line. To begin with we give a brief introduction to the real number system.

Mathematically, a number is called a rational number, if it can be written in the form $\frac{p}{q}$, where p and q are integers and q≠0 and is called an irrational number if it cannot be written in the form $\frac{p}{q}$. Now in real sense, the rational numbers include whole numbers, terminating and recurring decimal numbers whereas the irrational numbers are non-terminating and non-recurring decimal numbers, for example 1.010010001…is an irrational number. The collection of all rational numbers and irrational numbers together make up what we call the real numbers, denoted by R. Therefore, a real number is either rational or irrational. Also, every real number is represented by a unique point on the number line and vice versa.

Sample Problem: Show how the irrational number $\sqrt{5}$ can be represented on the number line

Solution: The following steps of construction in the solution of the above problem is shown in Figures 1 and 2.

1. On the number line, choose points A = 0 and B = 1. Now line segment AB is of unit length. Construct BC of unit length perpendicular to AB. Join the points A and C to get a right triangle ABC. Using the Pythagoras theorem, we see that AC = $\sqrt{1^2 + 1^2}$= $\sqrt{2}$.
2. Construct CD of unit length perpendicular to AC. Join A and D to get a right triangle ACD. Now using Pythagoras theorem, the length of hypotenuse, AD= $\sqrt{\left(\sqrt{2}\right)^2 + 1^2}$ = $\sqrt{3}$
3. Again, construct DE of unit length perpendicular to AD and join AE to get a right triangle. Similarly, as in the above steps we get, AE = $\sqrt{(\sqrt{3})^2 + 1^2}$ = $\sqrt{4}$. Continuing the similar procedure by constructing EF of unit length perpendicular to AE and joining AF, we get AF = $\sqrt{(\sqrt{4})^2 + 1^2}$ = $\sqrt{5}$.

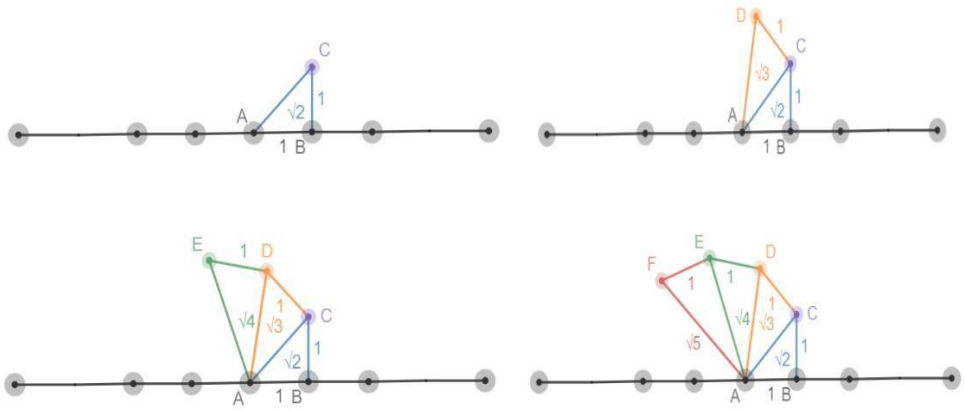

Figure 1: Steps of the solution

4. Using a compass, with centre A and radius AF, draw an arc which intersects the right side of the number line at a point which represents $\sqrt{5}$.

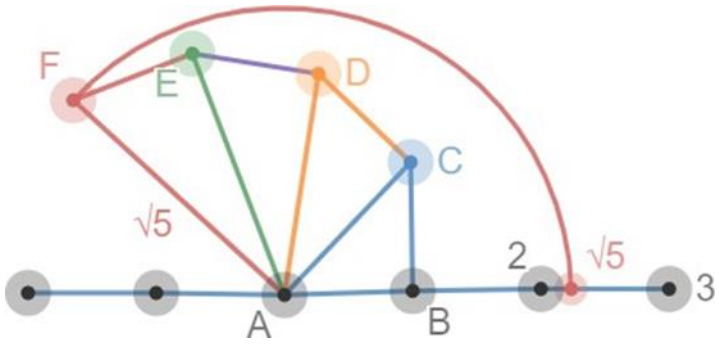

Figure 2: Representation of an irrational number $\sqrt{5}$ on number line

Square root spiral: The following Figure 3 shows a beautiful spiral depicting $\sqrt{2}, \sqrt{3}, \sqrt{4}, \ldots$ and their representation on the number line.

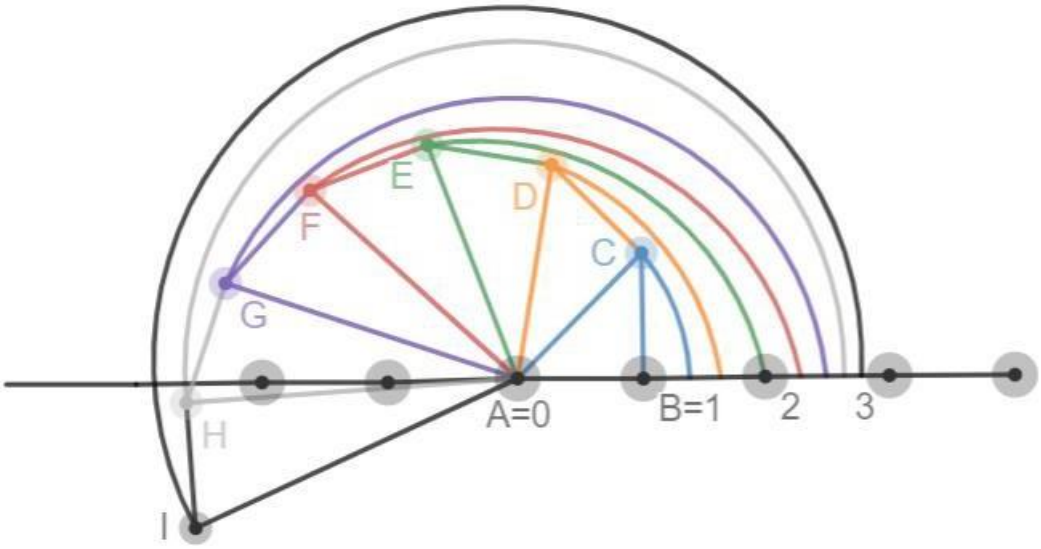

Figure 3: Square root spiral

The following table demonstrates different irrational numbers in the above Figure 3 with their respective colours of arcs on number line.

Irrational number	Color of arc
√2	Blue
√3	Orange
√4	Green
√5	Red
√6	Violet
√7	Grey
√8	Black

Table 1: Irrational Numbers and Colour of Arcs

The above construction helps the students to internalize some very important features of the number line, representing the set of real numbers R, which are discussed as below:

- Well Ordered property of the real numbers, i.e. given any two real numbers x and y, one and only one of the following is true: $(i) x < y (ii) x = y (iii) x > y$. The real line is ordered from left to right, meaning while comparing any two numbers, we know that the number on the right is bigger. Thus, for square roots, it can be seen very easily seen that $2 = \sqrt{4} > \sqrt{3} > \sqrt{2} > \sqrt{1} = 1$ [Fig.3] or we can say that if

$n > m$. we have $\sqrt{n} > \sqrt{m}$.

- Denseness of the set of rational numbers and set of irrational numbers, i.e., the numbers in the number line are not isolated points but are densely packed in it. More specifically, we can say that there is no next real number in the real line. From the definition of irrational numbers, we know that irrational numbers are non-terminating and non-recurring decimal numbers, say for example $\sqrt{2} = 1.4142135$ ..... and $\sqrt{3} = 1.73205080$ .....Now, we can find an infinite number of rational numbers between these two numbers such as 1.5, 1.51, 1.511, 1.5111,…..Similarly, between any two rational numbers, say 1 and 2, we can find an infinite or rather uncountable number of irrational numbers say $\sqrt{2}$, $\sqrt{2.1}$,$\sqrt{2.11}$,…..and so on. Visualization of this concept with the software tools helps them to understand the abstract concepts of limiting values of functions, continuity, and differentiability to a greater extent in further studies.

Hence, we see that the abstractness in the mathematics can be reduced by adding visualization with software tools in online as well as classroom teachings. This will add a great value to the mathematical understanding of the students and applying it for studying the infinitesimally small to infinitely large objects in the Universe, recognize patterns around them and many such things in their respective courses.

The following is the link for the video of the above construction which we have prepared and uploaded on YouTube: https://youtu.be/jlatb0MK_NA

Also, we discuss about another problem in Geometric constructions in Mathematics with the help of Desmos Software. The standard method of constructing the angle bisectors can be demonstrated with the help of the software, which is very easily grasped by the students, even in virtual mode of teaching. The link for the lecture is: https://youtu.be/YG6UUwqwwUs

We have made an effort to get feedback for the video lecture containing the solution of the Sample problems from a teacher Ms.Tannvi Trivedi, presently teaching Mathematics to class IX students and from a group of randomly selected class IX students. Ms. Trivedi has found this software tool to be useful for explaining the problems involving construction in Geometry.

The Feedback of a Group of Class IX students is as follows:

- Venkata Sai Sachin, Class IX: The video was excellent. I understood the concept of representation of irrational numbers and got all my doubts cleared.
- Dutt Parmar, Class IX: The video was great, and the way of teaching was also great. Now representation of irrational numbers on number line is clear to me.
- ShauryaThaplyal, Class IX: This was really a great knowledge and easier way to do a very important topic. This will really help me. Great work and thank you for the effort.
- Neel Shah, Class IX: This video gave a clear understanding of how $\sqrt{5}$ is represented on number line. Also, more videos of this kind can be very helpful.
- Parth Dighe, Class IX: I liked this video very much. Clear concept. Depiction is good. Points are explained very clearly.
- Monit, Class IX: This video is very useful as the Number systems topic is quite difficult. But with this video all my doubts about representation of irrational numbers are cleared.

Conclusion

The world as we know has changed irreversibly with Covid-19. Virtual classrooms are now the de-facto mode of teaching in schools and colleges. Without visualization of the mathematical models, students would not be able to comprehend the intricacies of the subject and learning may become mechanical with the routine problem-solving approach. Traditionally, the geometrical problems were taught using black board and wooden geometrical tools. However, in the online teaching scenario, teachers are mostly teaching remotely and do not have access to the earlier tools they were familiar with. In this situation, software technology tools can be of great help and can even be incorporated with regular classroom teaching after pandemic is over. Necessary software tools are available for instructors on internet, free of cost and are very easy to learn without any requirement of formal training.

A good fundamental knowledge of the subject at an early stage in student life will make it easy for them to understand the advanced knowledge of the related subjects as they progress.

We hope that our perspective encourages the instructors to think and work in the direction of modifying the age-old teaching methods for those branches of science which are complex and needs visualization for effective understanding of the nuances of the subject. For further readings, we suggest the following literature, which we found extremely valuable towards developing this manuscript.

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A Study on Evolution of Models Measuring Entrepreneurial Intention

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Abstract

Over the years, the studies in the domain on Entrepreneurship have evolved from discussing traits and demographic variables to intentions in determining entrepreneurial behaviour. The current study focuses on evolution of entrepreneurial intention as the closest predictor of entrepreneurial behaviour. The various entrepreneurial intention models are discussed and their antecedents are compared and contrasted. The systematic appraisal of all entrepreneurial intention models revealed that entrepreneurial self-efficacy is the best pre-dominant construct influencing entrepreneurial intention. The construct is ubiquitous in the majority of the models proposing the need for a scientific tool for measuring self-efficacy for the appropriate measure of entrepreneurial behaviour.

Keywords

Entrepreneurship, Entrepreneurial behaviour, Entrepreneurial intention, Self-efficacy

Introduction

The positive impact of entrepreneurship on generating employment, fostering growth, and providing an innovative solution to crucial problems of the economy has drawn the interest of the government in promoting entrepreneurship aggressively. This is mirrored by varied initiatives and schemes of government to foster entrepreneurship like the Start-up India initiative, Atal Innovation Mission, Student Start-up and Innovation Policy, and many more. New Education policy also emphasizes exposing the students to entrepreneurship as a major

career options. Most of the universities across the country are offering compulsory or elective courses on Entrepreneurship. Also, government-aided, as well as private incubators across the nation are promoting and nurturing new ideas and businesses. Currently, India is considered the third-largest start-up ecosystem in the world with more than 55000 start-ups, this is expected to surge to more than 100000 start-ups by 2025[1].

The conclusive success of entrepreneurship initiatives can be appraised through new venture creation, but these initiatives may not lead to immediate venture creation. This has encouraged the academic interest in understanding the pre-determinants of entrepreneurial decisions and actions. The following sections of the paper deliberate and debates the antecedents of entrepreneurial actions used for measuring entrepreneurial behaviour over the years.

The major advancement in Measuring Entrepreneurial Behaviour

The early literature of the 19th and 20th centuries advocates that the decision of pursuing entrepreneurship is primarily dependent on the traits of the individuals. Individuals possessing certain traits like the need for achievement [2,3]; risk-taking capability [2,4]; internal locus of control [4,5]; tolerance of ambiguity[3]; pro-activeness[6] etc. are expected to exhibit the entrepreneurial behavior.

Another set of studies focuses on demographic factors like gender, age, family background, education, prior experience[6,7,8]as the major contributors to the entrepreneurial choice of the individuals. However, largely it is agreed that entrepreneurial behavior is much more complex to be simply predicted with demographic variables like age, gender, family background, etc.[9]. Both, personality theory and demography served as the major approaches in the study of entrepreneurship decision making for a long time.

In 1989, Gartner strongly suggested that the focus of entrepreneurship research should shift from entrepreneurial traits to organizational emergence[10]. The personality traits approach for measuring entrepreneurship quotient was not developed specifically for the field of entrepreneurship but rather was borrowed from psychology. Researchers also found that most of the traits considered in entrepreneurship research, were common to any successful person, not necessarily an entrepreneur, and proclaimed that mere presence of these traits cannot be considered as determinants to choosing an entrepreneurial career[9,10,11,12,13]. The shortcomings

of personality and demographic approaches in predicting entrepreneurial behaviour stimulated the need for developing new paradigms to predict entrepreneurial behaviour. As a consequence, entrepreneurial intention emerged as the alternative approach for measuring entrepreneurial behaviour. This approach had the capability for considering new constructs for measuring entrepreneurial behaviour and at the same time also incorporating the important and relevant personal characteristics.

Barbara Bird in 1988 proposed that entrepreneurial intention strongly determines the action of the entrepreneur towards new venture creation even to the extent of subsequent organizational outcomes like survival, development, growth, and changes[14]. Intentions depend upon the situation as well as the person and hence can be a better predictor of behavior as compared to person or situation individually. Intentions are considered to be the best predictor of any planned behavior and as entrepreneurship is a planned behavior, various studies consequently found intention as a major determinant of entrepreneurial behavior[12,15,16,17]. Intention refers to the state of mind directing a person's attention, action, and experience towards a specific goal to achieve some means. The intention is a function of belief that forms the attitude and finally determines behavior as suggested by Fishbein & Ajzen in 1975in their Theory of Reasoned Action[18]. Their theory suggests the following linear path of beliefs transforming to actions:

Beliefs —> Attitudes —> Intentions —» Behavior

Following the significance of entrepreneurial intention in predicting entrepreneurial behaviour, various intention models have been proposed since the late 20th century. The next section of the paper deliberates on these intention models.

Discussion and comparison of Entrepreneurial Intention Models

Some of the notable intention-based models in the literature are Social Learning Theory, Self-efficacy Theory, Sokol's model of the entrepreneurial event (SEE), Bird's Intention model, Ajzen's Theory of Planned Behaviour (TPB), Entrepreneurial Potential Model, Entrepreneurial Intention Model, etc. The following section discusses the evolution of intention models applied for measuring entrepreneurial intention over the years.

i. Social Learning Theory (1977):

The social learning proposes that the behavior is roughly planned before it is performed. It suggests psychological functioning as the interplay of inner forces and controlling behavior.

Accordingly, human behavior is a combination of stimulus, cognitive skills, and reinforcement control. Behavioral patterns of the people are formed as a result of learning from direct experiences as well as learning from observing the behavior of other people (modelling). The cognitive skills of an individual determine what he/she learns from his own experience and experiences of others and how it influences his/her future actions. Reinforcement also plays a critical role in forming the behavior of an individual. People tend to discard the actions which are unrewarding and frequently perform those which are positively rewarded. There is a continuous interaction between the behavior and the three controlling factors of behavior i.e. stimulus, cognitive skills, and reinforcement that determine the actions of an individual[19].

ii. Self-efficacy Theory (1977):

As an extension to Social Learning Theory which proposed that cognitive processes are primarily responsible for the acquisition and retention of new behavior, Self-efficacy theory elaborated on these cognitive processes. According to it, the two cognitive activities that predominantly motivate an individual to behave in a particular manner include the cognitive ability to foresee the rewarding or punishing outcome of the current behavior (outcome expectancy) and self-evaluation of an individual to be able to perform a particular behavior (self-efficacy).

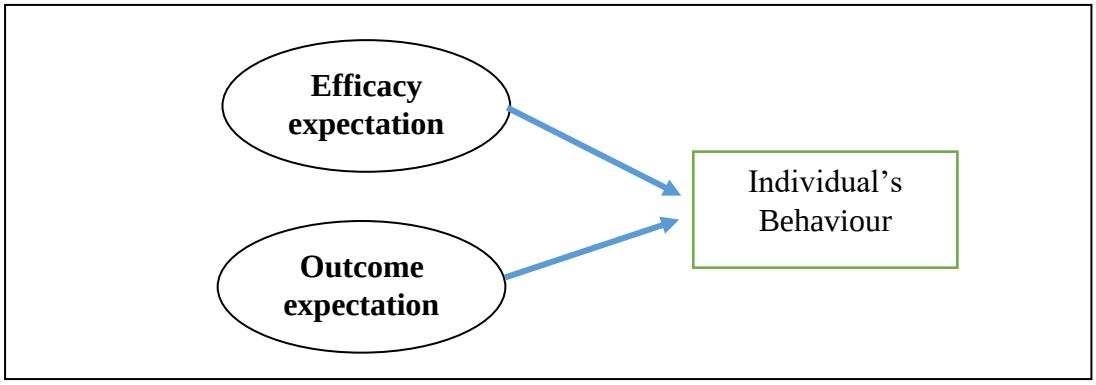

Figure 1: Self-Efficacy Theory[20]

According to this theory, self-efficacy is the primary influencer of the behavior of an individual. It not only determines the choice of activity, but also the amount of effort and their persistence in the difficult situation faced during performing the selected action.

Self-efficacy theory states that the level and strength of self-efficacy can be enhanced through psychological procedures.

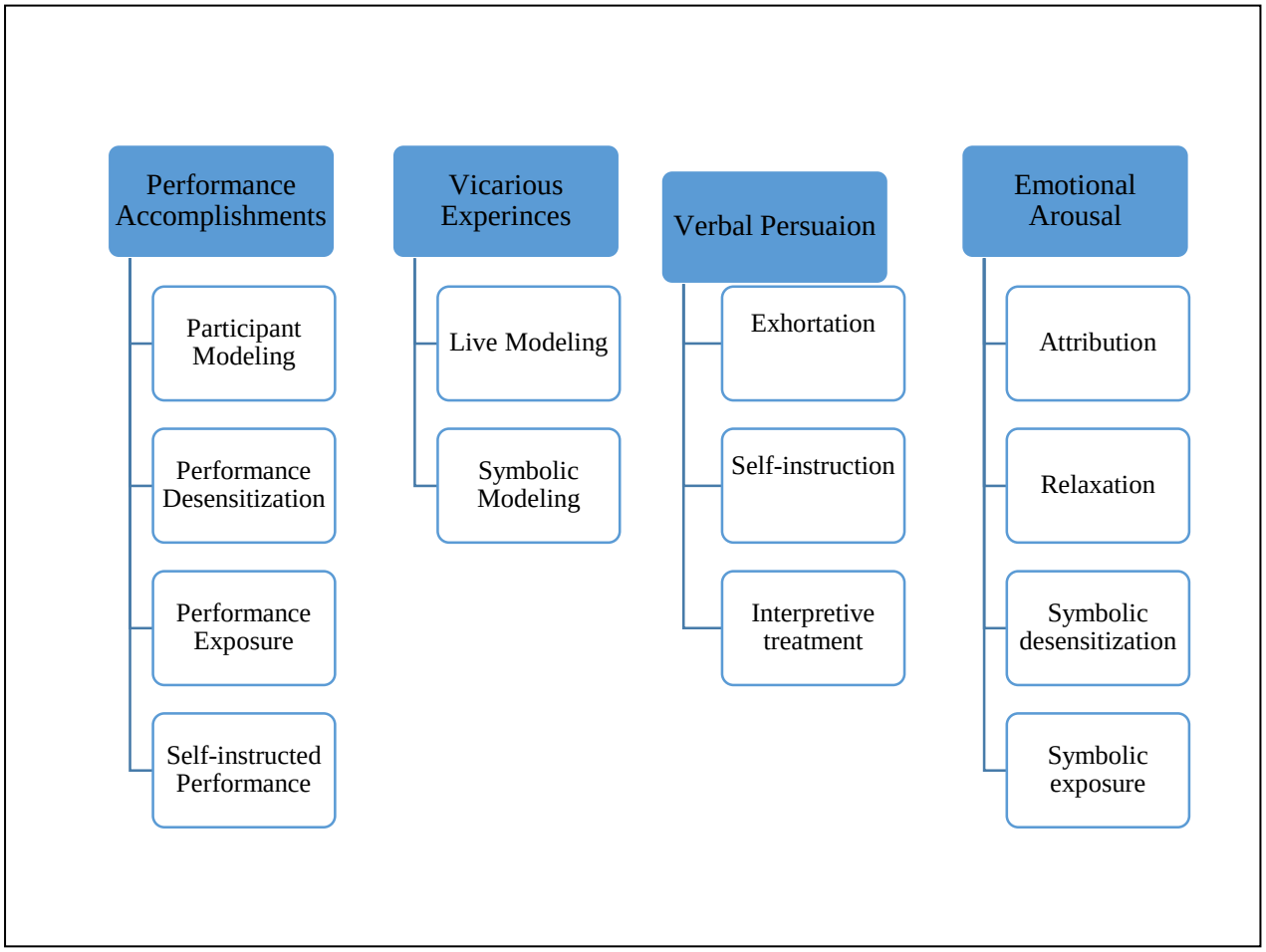

Figure 2: Sources of Self-Efficacy[20]

The theory proposes four cues i.e. performance accomplishments, vicarious experience, verbal persuasion, and physiological states are the major determinants of self-efficacy[20]. Figure 2 provides the diagrammatic representation of four main sources of self-efficacy and their sub-components.

iii. Shapero's Entrepreneurial Event (SEE) Theory (1982)

SEE theory proposed by Shapero & Sokol in 1982, is considered to be the first model that specifically focuses on entrepreneurial intention and behavior[21]. According to this theory, entrepreneurial intention is a function of perceived feasibility, personal desirability, and propensity to act. It gives significant importance to the perception of the individual towards attractiveness (perceived desirability) and towards his/her capability of starting a venture(perceived feasibility). Of the three factors contributing to the intention, perceived feasibility has been found to have the highest predicting power. Perceived feasibility and perceived desirability in turn is influenced by prior entrepreneurial experience. Kruegerempirically tested the SEE model and even examined the different path models including the direct impact of prior exposure on entrepreneurial intention. It was found a significant impact of prior experience on intention is mediated through perceived feasibility as suggested by SEE and positive prior experience also influence intention by impacting perceived desirability[22].

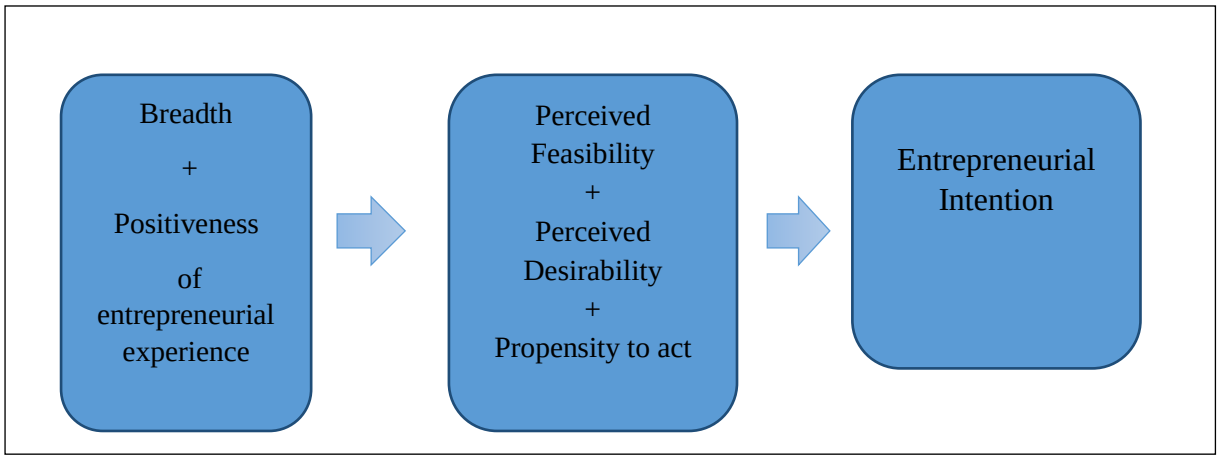

Figure 3: Shapero-Sokol Model of Entrepreneurial Event[21]

iv. Theory of Planned Behavior (1985)

The theory of planned behavior proposed by Ajzen is an extension of the Theory of Reasoned Action. It proposes that the intention is formed based on attitude towards behavior, subjective norms, and perceived behavioral control. Attitude refers to the degree to which a person has a favourable or unfavourable evaluation or appraisal of the behavior in question. Subjective norm refers to the perceived social pressure to perform or not to perform the behavior and whether people will approve of the particular behavior. Perceived behavioral control refers to

the perceived ease or difficulty of performing the behavior based on the experience, anticipated future obstacles, availability of plan of action, and general self-knowledge[23]. Perceived behavioral control is almost synonymous with the concept of self-efficacy proposed by Bandura in 1977. It also empirically established the relationship between perceived control and behavioral performance. A study based on the Theory of Planned Behavior by Ajzenin 1991 advocatedthe predictive ability of perceived behavioral control along with the intention towards the behavior of an individual[24].

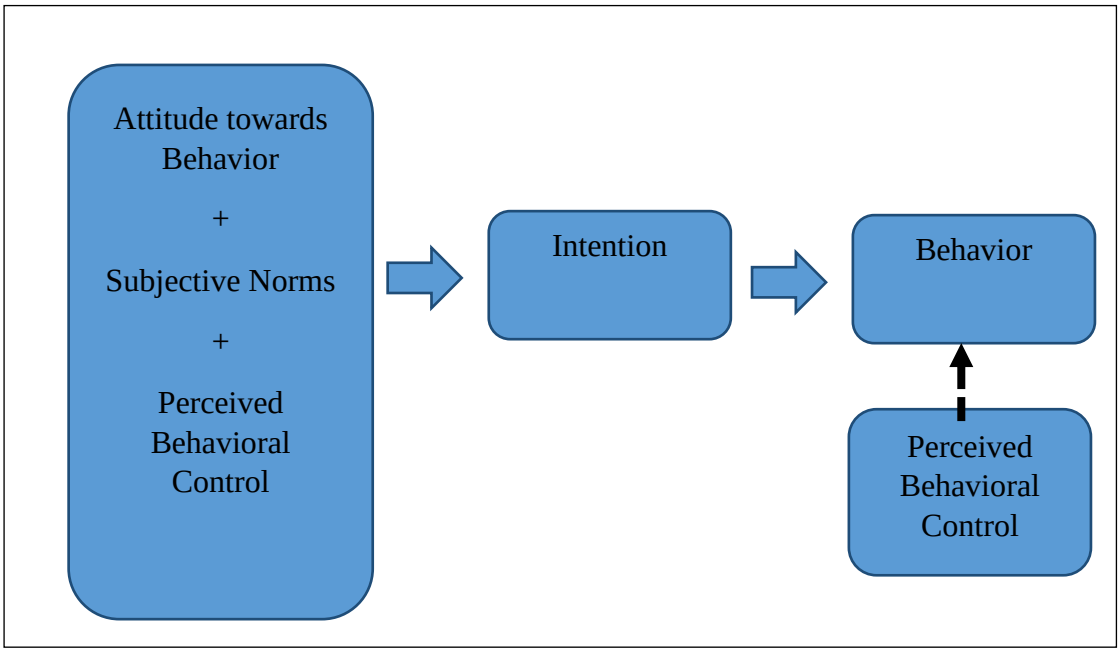

Figure 4: Theory of Planned Behavior[23]

v. Bird's Entrepreneurial Intention Model (1988)

Entrepreneurial intention directs the person towards creating a new venture or creating new ideas within the existing venture. Bird in 1988proposed a framework of Entrepreneurial Intention as interplay rational and intuitive thinking derived from personal and social context (illustrated in Figure 5). The personal factors include prior experience, personality characteristics like locus of control, and abilities like promoting ideas whereas contextual factors affecting the intention include social, economic, and political factors like government regulation, economic scenario, etc. The rational thinking of an individual is framed based upon factors like resource availability, idea feasibility, opportunity analysis whereas intuitive and holistic thinking is influenced by gut feeling and a hunch about the potential of the idea[14].

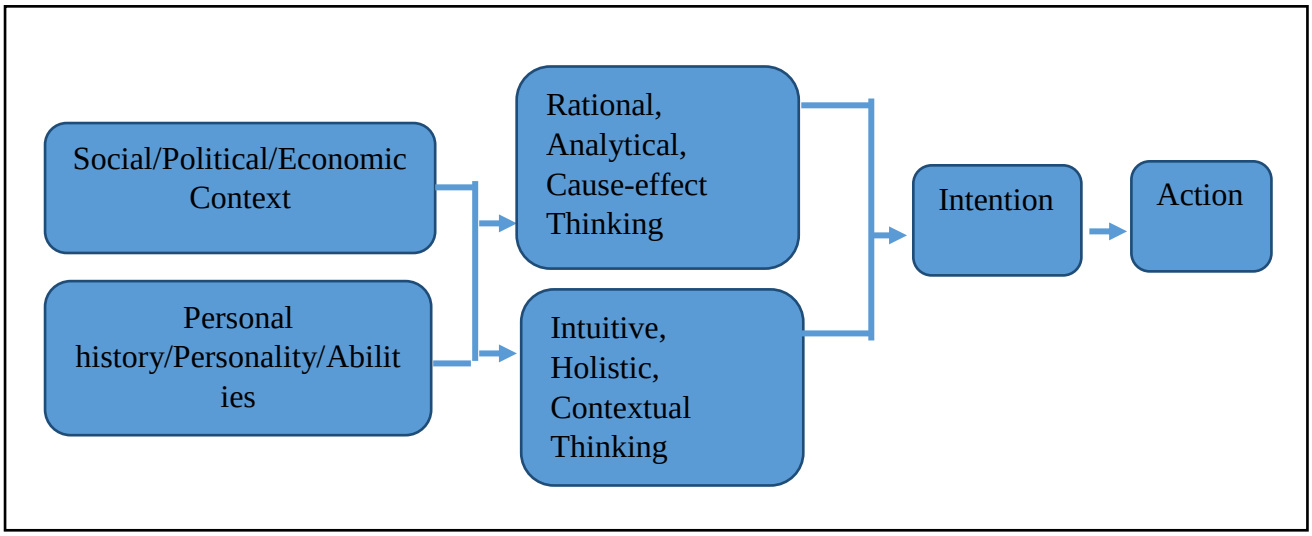

Figure 5: The contexts of intentionality[14]

v. Entrepreneurship Attitude Orientation (EAO) Model (1991)

Robinson, Stimpson, Huefner & Hunt also proposed a model to predict entrepreneurial behavior beyond demographics and personality traits[9]. Their EAO model recommended four attitude sub-scales based on their wide-spread and repeated reference in studies about entrepreneurship to distinguish entrepreneurs from non-entrepreneurs. The subscales of the proposed model included achievement in business, business innovation, perceived personal control of the business outcome, and perceived self-esteem in business.

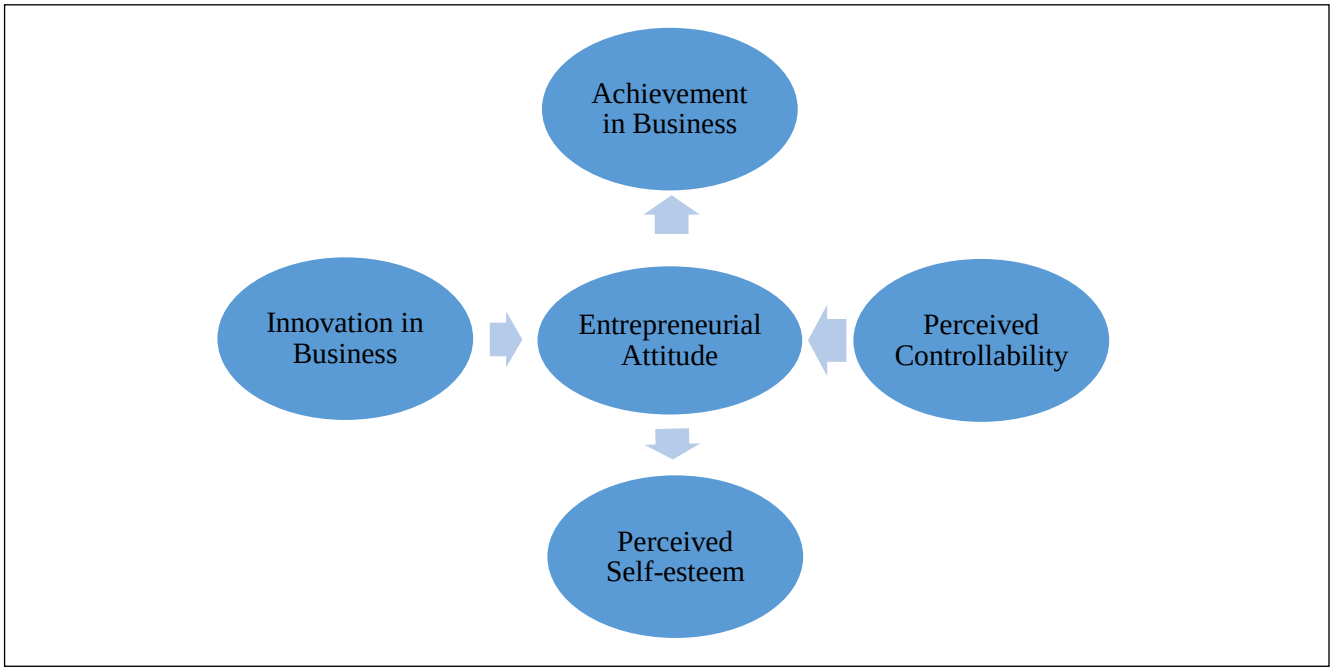

Figure 6: Entrepreneurship Attitude Orientation (EAO) Model[9]

Each of the four attitudinal subscales was measured on three aspects of attitude- cognitive, affect, and conation for entrepreneurs as well as non-entrepreneurs. The construct of perceived personal control refers to the perception of control over one's business and perceived self-esteem pertains to one's confidence and perception about being competent in conjunction with the needs of the business. The results indicated significant differences in the attitude of entrepreneurs' vs non-entrepreneurs on each of the four subscales of attitude validating the significance of EAO. The model is relevant and validated empirically in various consequent studies[25,26,27].

vi. Modified Bird's Model of Entrepreneurial Intention (1994)

Boyd & Vozikis in 1994 proposed that self-efficacy is an important explanatory variable in determining entrepreneurial intention and hence should be integrated into Bird's model of entrepreneurial intention[28]. The significance of self-efficacy in determining the intention was also advocated earlier in Ajzen's Theory of Planned behavior in the form of perceived behavioral control and Shapero and Sokol's SEE theory as Perceived desirability. Theself-efficacy was integrated into Bird's model at two levels; as the precursor to the intention and also as a moderating variable between entrepreneurial intention and entrepreneurial action (illustrated in Figure 7).

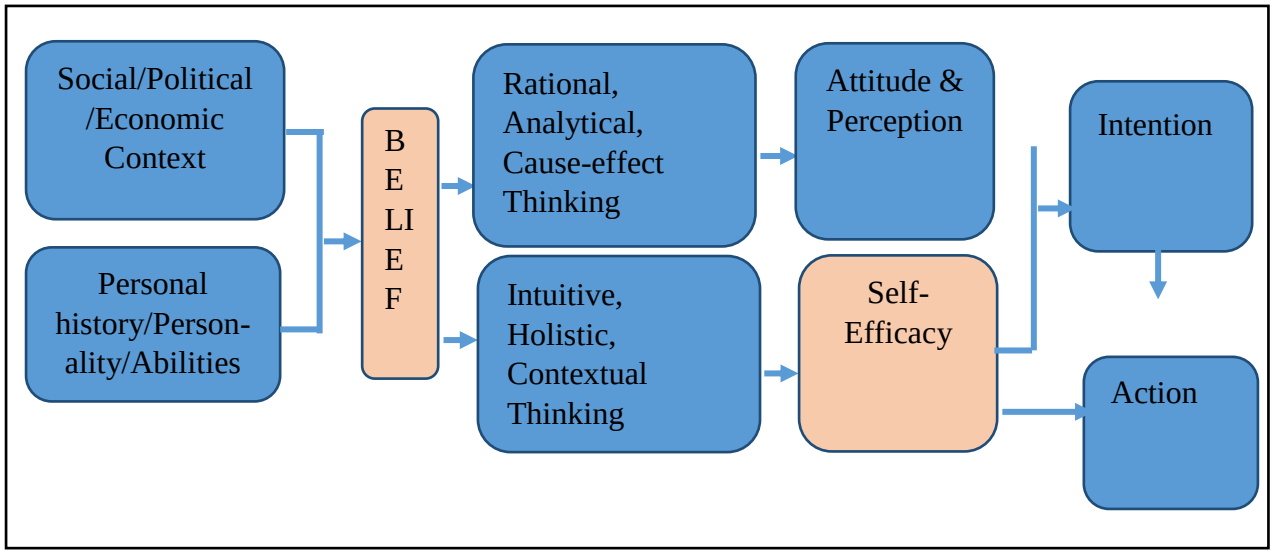

Figure 7: A revised model of Bird's (1988) Contexts of Intentionality[28]

The model suggests that an individual select only those activities and setting which he/she assumes to be capable of based on self-judgment. The model also proposes that not every entrepreneurial intention results in entrepreneurial action. Only when an individual's self-efficacy for the tasks required for entrepreneurial action is high, entrepreneurial intention results in action.

vii. Entrepreneurial Potential Model (1994)

Krueger and Brazeal in 1994 proposed Entrepreneurial Potential model (EPM) which suggests that the potential of the entrepreneur precedes entrepreneurial intention. The preparedness or potential of the entrepreneur, in turn, is determined by the constructs proposed in SEE i.e. perceived feasibility, perceived desirability, and propensity to act. It further advocated the robustness of Shapero's model and regarded feasibility perceptions (self-efficacy) as the major contributor to explaining intention[29]. The model was empirically validated by various researchers [30,31,32].

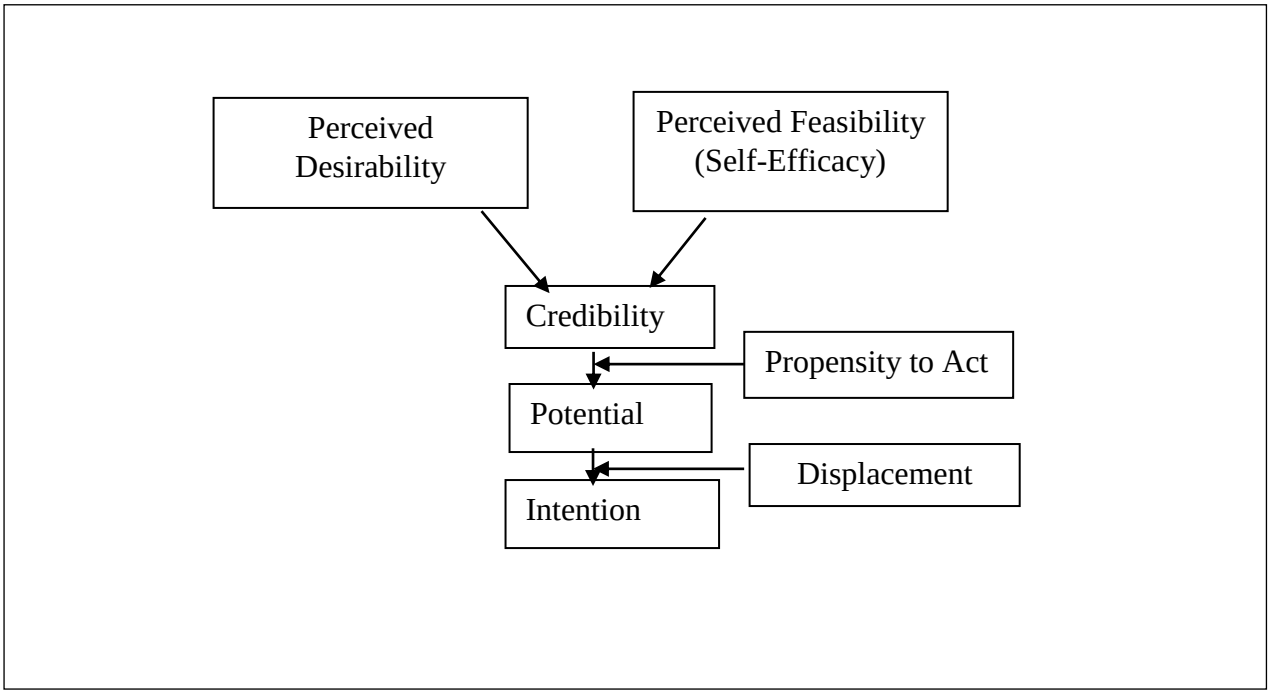

Figure 8: Entrepreneurial Potential Model[29]

viii. Davidsson Model (1995)

Another model for measuring entrepreneurial intention was proposed by Davidsson in 1995[33]. It was considered as the latest model for measuring entrepreneurial intention till 2008[31].Davidsson's model takes into account psycho–economic factors determining entrepreneurial intention. He integrated the already existing determinants from the various theories and models like SEE, TPB, Bird's intention model, Entrepreneurial Potential model and other studies encompassing cultural and structural influences into a single model. According to this model entrepreneurial intention is determined by conviction and situation (i.e. current employment status). Conviction in turn is determined by general attitude (willingness to change, competitiveness, achievement motivation, and need for autonomy) and domain attitude (expected pay off, societal contribution, and perceived know-how). The general and domain attitude are also influenced by personal factors like age, gender, education background, vicarious experience, and radical change experience. Empirical testing of the model revealed the direct or indirect influence of all the variables included in the model but the conviction was found to be the highest influencing variable. Conviction is similar to the concept of self-efficacy proposed by Albert Bandurain 1982[34].

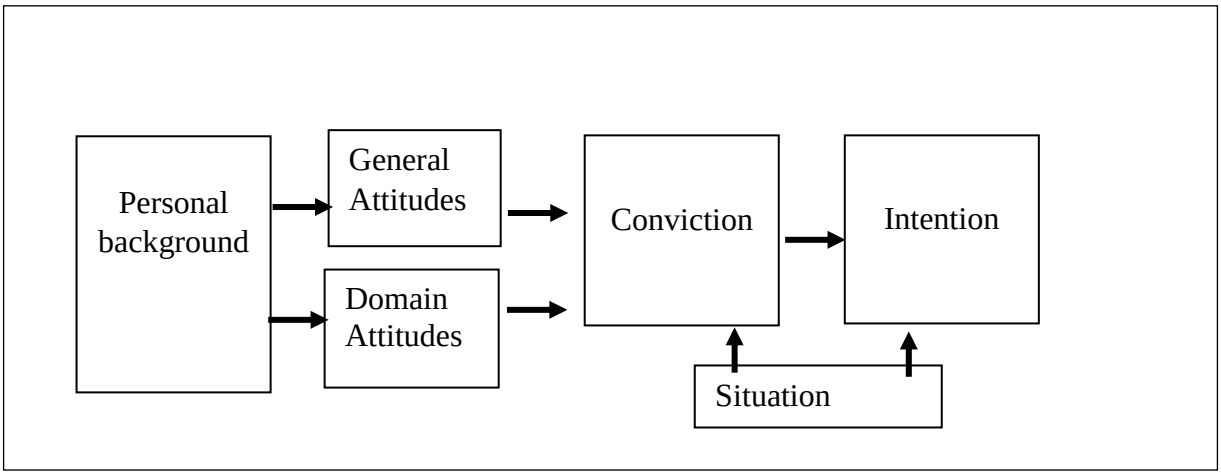

Figure 9: Davidsson Model[33]

ix. Entrepreneurial Intention Model-EIM (2000)

Segal, Borgia & Schoenfeld in 2000 proposed another integrated model for predicting and measuring the entrepreneurial intention based upon the Shapero-Krueger framework and

other economics-based models of entrepreneurial intention. According to this model, the perceived desirability of pursuing entrepreneurship would be based on one's perception of higher valuable outcomes of pursuing entrepreneurship as compared to working for others. The net perceived advantage of self-employment over working for others designated as Perceived Net Desirability of self-employment would be one of the determinants of entrepreneurial intention. Another important modification in the model proposed by them was based on the rationale that an individual's propensity to act entrepreneurially will be highly dependent on his/her willingness to take calculated risks[35]. Figure 12 represents the EIM

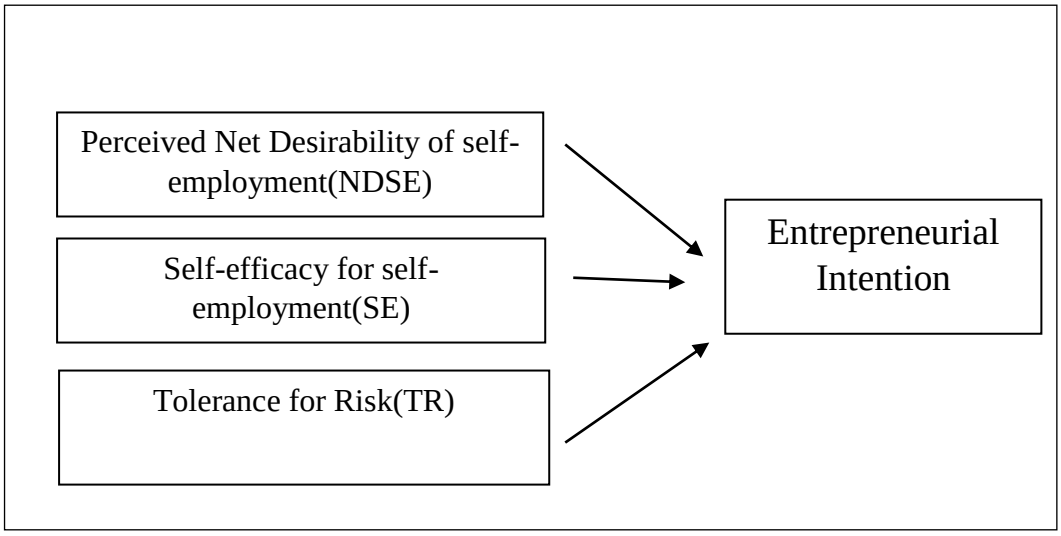

Figure 10: Entrepreneurial Intention Model[35]

x. Extended Models

a) Extension of Systemic Entrepreneurship Intention Model-SEIM-(2019)

Díez-Echavarría, Valencia, Bermúdez-Hernández, Orlando, Lucelly & Adolfo in 2019 proposed an extension of EIM including new constructs for determining entrepreneurial intention. The proposed model suggested additional constructs of entrepreneurial behavior and personal attitude to be incorporated along with the existing determinants[36].

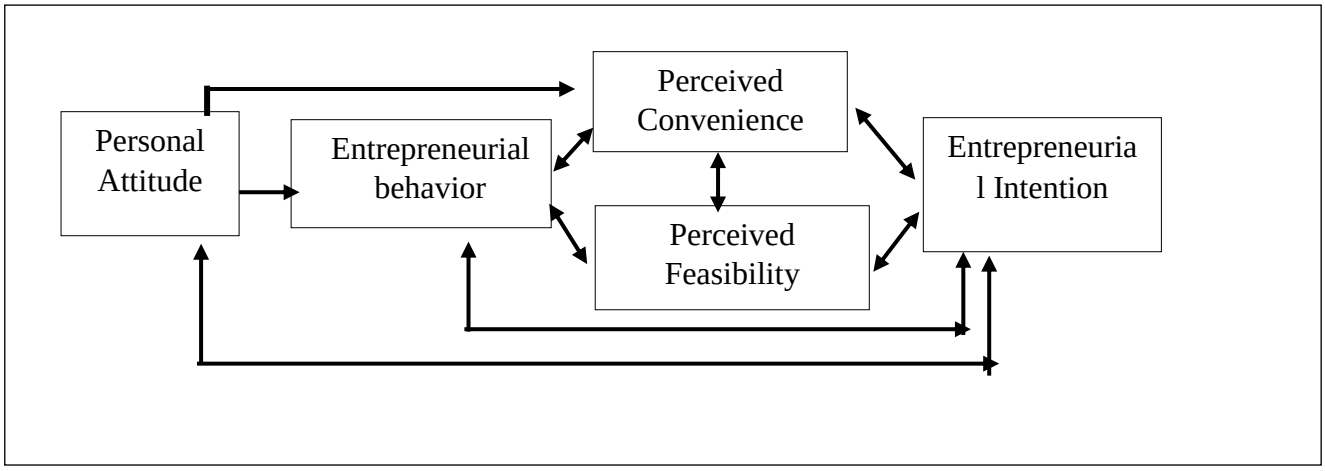

Figure 11: Extension of Systemic Entrepreneurship Intention Model-SEIM-(2019)

b) Hierarchal Model of Perceived Behavioral Control (2002)

Ajzen in 2002 further elaborated on the construct of perceived behavioral control and created a Hierarchal Model of Perceived Behavioral Control. Perceived behavioral control, comprises self-efficacy and controllability. Both are distinguished in the manner that self-efficacy is ease or difficulty in performing a particular action whereas controllability is the extent to which performance of particular action is within the control of an individual. The model also proposed that both self-efficacy and controllability are influenced by factors internal to an individual as well as external factors and some of these factors may overlap in influencing both self-efficacy and controllability[37].

Findings

As intention models are found to demonstrate high predictive ability of consequent entrepreneurial behavior, the entrepreneurial intention and its antecedents appear to be most relevant measures for examining the entrepreneurial behavior of an individual since the actual behavior is a long term phenomenon and hence difficult to observe considering the time-frame of most of the research works.

Various empirical studies have also demonstrated the significant contribution of different variables included across these models in predicting entrepreneurial intention as well as entrepreneurial actions. Souitaris, Zerbinati & Al-Lahamin their study on entrepreneurial intention using TPB found positive correlation of all the three antecedents in the model i.e.

attitude(r=0.42), subjective norms (r=0.53) and perceived behavioural control(r=0.39) with entrepreneurial intention[38]. Another study establishing the significance of Entrepreneurial Potential Model found statistically significant relationship of entrepreneurial intention with perceived desirability and feasibility at 99% confidence level[31].Sanchez in their study on entrepreneurial competency and intention of students in Spain observed positive correlation between like self-efficacy (r=0.44), pro-activeness(r=0.4) and risk(r=0.27) with entrepreneurial intention[39]. Kolvereid in his study on Norwegian students found strong correlation (r=0.598,0.452,0.6) between self-efficacy, attitude and subjective norm with entrepreneurial intention respectively. Moreover, the influence of demographic variables on self-employment choice was also mediated through attitude, subjective norms and perceived self-efficacy[15]. Krueger, Reilly & Carsrud also advocated that the influence of personal and situational factors is mediated through antecedents of entrepreneurial intention rather than directly influencing entrepreneurial intention thereby proposing the significance of studying antecedents of entrepreneurial intention[12].

Table-1 summarizes various antecedents of different entrepreneurial intention models discussed in the previous section to identify the most commonly occurring variables across all models.

Table 1: Comparison of antecedents of entrepreneurial intention in various Entrepreneurial Intention Models

S.No	Author	Year	Model	Variables Included									
				Perceived Feasibility	Perceived Desirability	Attitude	Social Norms	Propensity to Act	Outcome expectation	Perceived Controllability	Personal, Economic, Political Factors	Rational and Intuitive Thinking	Other factors
1	Albert Bandura	1977	Self-efficacy Theory	Efficacy expectation					Outcome expectation				
2	Shapero and Sokol	1982	Shapero Entrepreneurial Event	Perceived Feasibility	Perceived Desirability			Propensity to Act			Prior Entrepreneurial Experience		
3	Ajzen	1985	Theory of Planned Behavior	Perceived behavioral control		Attitude	Social Norms						
4	Bird	1988	Bird's Entrepreneurial Intention Model				Social Factors				Personal, Economic, Political Factors	Rational and Intuitive Thinking	
5	Boyd &Vozikis	1994	Revised Model of Bird's Entrepreneurial Intentionality	Self-efficacy		Attitude	Social Factors				Personal, Economic, Political Factors	Rational and Intuitive Thinking	
6	Robinson, Stimpson, Huefner& Hunt	1991	Entrepreneurial Attitude Orientation	Perceived self-esteem		Attitude				Perceived Controllability	Achievement in business		Innovation in Business
7	Krueger &Brazeal	1994	Entrepreneurial Potential Model	Perceived Feasibility	Perceived Desirability		Social Norms	Propensity to Act			Precipitating Event		

8	Davidsson	1995	Davidsson Model			General and Domain attitude					Age, Experience, Education, Gender		
9	Segal, Borgia & Schoenfeld	2000	Entrepreneur Intention Model	Self-efficacy	Perceived Net Desirability						Tolerance for Risk		
10	Ajzen	2002	Hierarchical Model of Perceived Behavioral Control	Perceived Self-efficacy			Social Factors			Perceived Controllability			
11	Ajzen	2019	Extension of Systemic Entrepreneurship Intention Model (SEIM)	Perceived feasibility	Perceived convenience	Personal Attitude					Risk Tolerance		Entrepreneurial Behavior

The different precursors of entrepreneurial intention as can be identified from Table-1 are:

i. Perceived feasibility
ii. Perceived desirability
iii. Social Norms/factors
iv. Perceived controllability
v. Attitude
vi. Outcome Expectations
vii. Personal factors(Demographic)
viii. Prior entrepreneurial experience
ix. Risk Tolerance
x. Rational and Intuitive thinking
xi. Innovation in business
xii. Economic factors
xiii. Political factors
xiv. Entrepreneurial behavior
xv. Entrepreneurial potential

Among all the antecedents of entrepreneurial intention, entrepreneurial self-efficacy is common across most of the entrepreneurial intention models. It is found to not only directly impact entrepreneurial intention but also moderate the impact of other variables like personal, economic, and political factors on entrepreneurial intention. Krueger, Reilly & Carsud in their empirical study validating the significance of competing models of entrepreneurial intention particularly TPB and SEE, also found that all antecedents were significantly related to entrepreneurial intentions but the entrepreneurial self-efficacy had stronger influence on entrepreneurial intention($p<0.005$) [12]. In another study by Hattab on the Egyptian students, regression analysis revealed that 95% of variation in entrepreneurial intention is attributed by self-efficacy and perceived desirability[40]. Literature suggests that self-efficacy do not only influence the choice of activity but also the effort one puts in any activity as well as the performance. A meta-analysis of 114 studies on self-efficacy by Stajkovic and Luthans found a significant weighted average correlation with r value of 0.38, between self-efficacy and work-related performance[41].

Research Gaps:

To propose a robust model predicting entrepreneurial behaviour, none of the existing research has considered all the constructs derived from various intention models in a single study. A comprehensive model measuring the contribution of all the identified antecedents on entrepreneurial intention will help in establishing the relative significance of each of the precursors of entrepreneurial intention. Further, all the entrepreneurial intention models are

developed in the western context, their application to studies about entrepreneurial intention in India and other developing countries may establish its validity further.

Conclusion:

The comparison of various models for measuring entrepreneurial intention suggests that perceived self-efficacy is the most pre-dominantly occurring antecedent of entrepreneurial intention in most of the intention models.

Various other studies have also empirically established that self-efficacy plays the most critical role in influencing the entrepreneurial intention[12,15,17,29,33, 35,42,43,44,45,46,47,48,49,50]. Zhao, Seibert, and Hills evaluated various models for the prediction of entrepreneurial intention found that the impact of all factors on entrepreneurial intention is fully mediated through self-efficacy. The models proposing the direct influence of education, risk propensity, and gender on the entrepreneurial intention were empirically disproved[51]. High entrepreneurial self-efficacy on the other hand was found to increase the perception of venture feasibility and opportunity[12] thereby not only directing entrepreneurial behavior but also influencing venture growth and success[52].

As perceived entrepreneurial self-efficacy has emerged as the most critical construct for determining entrepreneurial intention and entrepreneurial behaviour, and appropriate measurement of entrepreneurial self-efficacy can play a determining role in entrepreneurial studies. The impact of various interventions for enhancing and promoting entrepreneurial behaviour can be measured through observing the change in entrepreneurial self-efficacy.

Future Direction:

As the research highlights the significance of entrepreneurial self-efficacy in predicting entrepreneurial behaviour, a robust instrument for measuring self-efficacy would play a critical role in the entrepreneurship research domain. The existing instruments of entrepreneurial self-efficacy may be reviewed to analyze the advancement of research in that area and the need for further refinement and adaption of self-efficacy instruments.

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Virtual Classrooms: Challenges handled by the Schools and Muslim Girls in COVID-19 times: A Study of 10 Muslim Managed Schools of Vadodara

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Abstract

The pandemic Covid-19, that the world is facing has terrifying and severe impact which has stunned the entire world, distressing all the sectors of the economy. According to the UNICEF report[1], the coronavirus pandemic will badly affect over 290 million students across 22 countries.

With each passing day, with no direct solution to break the pandemic of Covid-19, the educational sector not only will have a temporary impact on the continuity of education for 285 million[2] Indian students but also will provoke a comprehensive economic and societal consequences. The structure of teaching and learning are very much affected by these closures and lockdowns. To combat with the situation, digital education only seems to be a practical option, till the classrooms recommence, which is initiated by the schools to ensure the continuity of education among the students.

Bearing in mind the participation of students in virtual classes, the participation of female students in Indian context, is limited as compared to the male students, and more precisely the participation of females belonging to the Muslim minority is an issue of concern, where the educational progress of Muslim girls is much lower according to the statistical Census data 2011.

This paper addresses the issues, challenges and measures adopted by the Muslim managed schools in Vadodara city, to support and to ensure continuity of education of Muslim girls studying in their higher secondary classes and the problems encountered by the Muslim girls in attending simulated teaching – learning process.

Keywords

Virtual Classes, Pandemic, digital education, higher secondary

Introduction

Covid-19 pandemic that the entire world is facing today is one of the largest public health risks, which has led its impact over, all the sectors of the country including education. The world saw that the pandemic has affected 185 countries[2] of the world by the period of March 2020. Because of the hit of the pandemic situations, majority of the countries had to momentarily shut down its educational institutions such as schools, colleges and universities. The prolonged shut down of the schools and universities has affected the educational system as a whole. The influence of this shut down and closures of the educational institutions will leave a deep effect among the nations wherein the education as a sector is handling the situations of high dropout rate among its students. This epidemic situation, has called for re-evaluation of our educational system, which demands for a comprehensive and inclusive education system. The situations have also laid down its long-term effect on the social institutions as well, which is a cause for social inequalities. The lockdowns and closures of schools have resulted in increase in dropout rates of girls. According to the Plan India's Executive Director in his interview with the Hindustan Times, published on 13th June ,2020 "The lockdown is burdening girls with household chores and sibling care,"Additionally it was stated thatincrease in dropout rates of girls from schools will also leads to increase in social problems like early marriages and child labor.

Explicitly, focusing on the educational status of Muslim girls, many earlier researches done in this context have portrayed the lower educational status among Muslim girls. Hasan and Menon[3] in their research volume, titled, "Unequal Citizens: A study of Muslim Women in India", the highlights the major problems impacting the lives of Indian Muslim women, the authors says that the Muslim community is of the belief that educating a girl child in the family will not be beneficial to the family. Additionally, the authors write parental attitude among Muslims is a responsible factor, for not sending their daughters for

education, as they are of the belief that it would be difficult for the parents to find a suitable marriage partner for the educated girl.

Recognizing the difficulties in the education of Muslims in India and suggest some recommendation so as to improve the educational status among Muslims, the study by Shazli and Asma[4] points that Muslims in India lag behind in many aspects like education, employment and associate the lack of education as the responsible factor for backwardness among Muslim community. The significant researches[5-9]done in this context, discloses that the cause of the educational backwardness among Muslim females is due to various sociocultural beliefs and practices, gender inequalities, teaching – learning process in schools. Amidst this situation of covid-19, wherein there is a rise of increase in the problems like poverty, unemployment among various families, which has hampered the educational progress of children within these families. On one hand, there is loss of family income for many families, many earning members of the family are searching new ways and means of earning their living, to satisfy the needs of themselves and their dependents, which ultimately has laid down its impact on the educational status of girls, specifically those from Muslim community, where education of girls is yet not considered as primary, In this pandemic situations , many girls have to compromise with their education, they are expected to participate in the household responsibilities and sibling care, because of the closure of schools and on the other hand the educational institutions are trying their best to retain students with the school, ensuring the students do not leave the schools because of financial constraints in the family, using digital platform for conducting online classes so as to keep the academic pace. The government through its policies have instructed the school authorities not to demand for fees from the parents.

The previous research as quoted above on the educational development of Muslim girls is demonstrating the issues such as lack of education and awareness among Muslims; the attitude of parents towards the education of their daughters; as the responsible factors for the lower educational position. Considering these situations, the contemporary paper looks in to the issues and challenges faced by the school authorities to continue their academic work through using digital technology on one hand, while on the other discusses the problems handled by the Muslim girls studying in higher secondary classes in the selected schools for the study.

Objectives of the study

1) To find out the measures adopted by the Muslim managed schools in recommencing the academic work for higher secondary classes in COVID times.
2) To understand the issues faced by Muslim girls in attending virtual classes.
3) To explore the challenges faced by the School authorities to conduct the online classes.

Size of the Sample

For Schools: Using stratified sampling method, the study was undertaken in 10 Muslim managed schools of Vadodara. Further explaining, total number of schools managed by Muslim trusts/ organizations or administrative bodies in Gujarat, the number of Muslim managed schools were stratified, further from the total number of schools, the number of Muslim managed schools with higher secondary section were stratified, which is diagrammatically explained in Figure-1.

For Muslim girls studying in Higher Secondary Classes:

Convenient sampling technique was used to identify the girls, from each school the sample size of 3 girls were chosen, hence in total 30 Muslim girls from 10 selected schools under the study were interviewed.

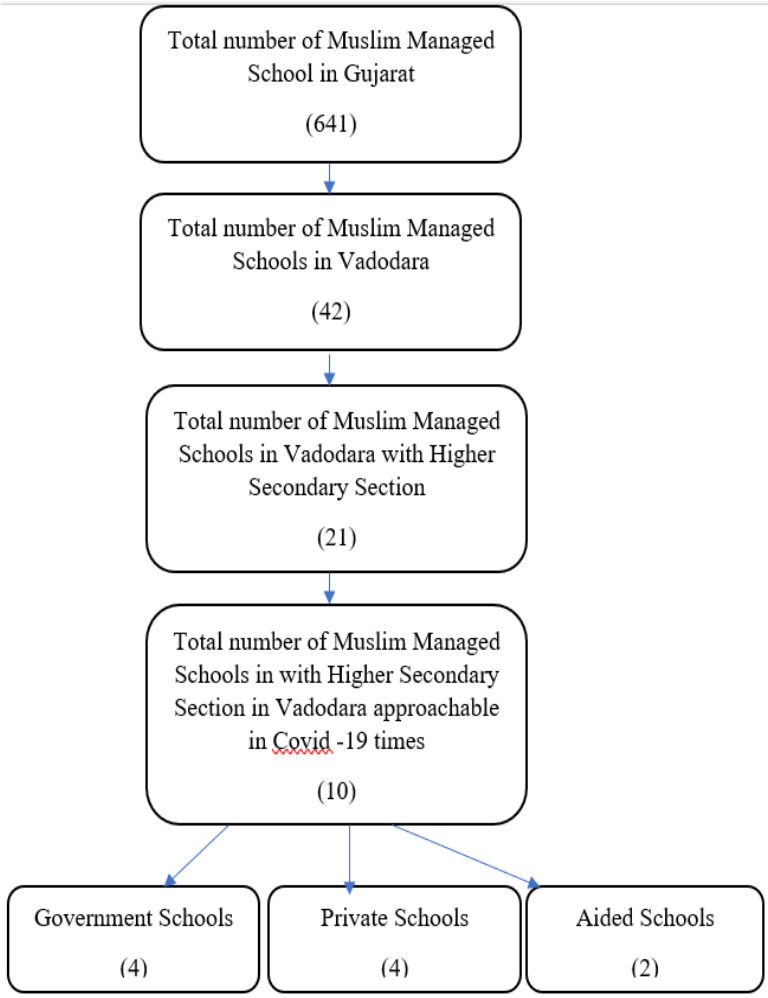

Figure 1:Showing the stratification of the sample

Data Collection tool and process

The researcher had telephonically contacted the head of the schools with prior appointment and informing them about the purpose of data collection, using an unstructured interview schedule with open ended questions. Similarly, the responses from the Muslim girls were also telephonically steered, with their prior consent through convenient sampling.

Duration of the Study:

The collection of information and documenting the case studies were undertaken during the period of March 2020 onwards.

Ethics followed in conducting a research

1) The data shared by the respondents are documented as narrated by them,
2) Confidentiality of the respondents is preserved by not citing their names in the case studies.
3) Confidentiality of the respondents is preserved by not naming the schools

4) Respondents were well informed in advance about the purpose of collecting the data.
5) Respondents were interviewed taking prior appointments.

School- A

School A, which is a government school situated in a sub-urban locality towards the East direction of the Vadodara city. The schools cater to the student population both boys and girls, belonging to the lower- and middle-income group families from the surrounding localities and other parts of the city as well. Initially the school planned to conduct the classes using the Google Meet application, however, the mode was not feasible.

Challenges faced by schools in conducting virtual classes

The problems that the school teachers faced was lack of smartphones with the students and also the unavailability and non affordability of internet facilities. It was reported that there is only one smart phone in the family and the phone is usually with the father. Since the phone is not at home, the students could not participate in the scheduled online classes. To overcome this issue, the teachers began to record their videos and started sending it to the students of their classes on the What's App group. So, the children can download the videos sent by their teachers and study, whenever the phones are accessible to them at home. The school authorities had a difficult time in the initial phase, as the teachers were not acquainted with the online teaching methods, hence it was a difficult time for teachers also to learn and conduct online teaching classes.

Participation of Muslim girls in virtual classes

Particularly focusing on participation of girls in online classes, the teachers reported that only 20-30% girls participated in the online classes, as it was not feasible for girls to participate in the online google classes because of household chores and lack of availability of phones at home. On deriving Muslim girls' responses from the school, the girls said that they cannot have a separate phone hence they cannot attend the classes, if the phone is not available at home. Moreover, some girls also shared that they are not able to attend the classes, as they have to help their mothers in the household chores.

Thus, because of the lack of availability of the smart phones at home, due to lack of income of the parents to afford a distinct phone for the education of girls, and responsibility of the domestic work, girls were not regular in their virtual classes, which has affected their education.

The attendance and regularity of the Muslim girls remains an issue in the school, regardless of various facilitative measures from the school authorities.

School-B

School B located in the East direction of Vadodara city, which is a Gujarati medium school only for girls. The schools also have adopted the online teaching methods, wherein the classes are conducted by using Zoom application for standard XI to XII.

Challenges faced by schools in conducting virtual classes

The school lacks the Wi-Fi internet facilities in the school, and hence the teachers were using their own mobile data pack to conduct their own classes. It was stated that in the initial stage, training of the teachers on using zoom platform for conducting the classes was undertaken and then the teachers began to use the application for the teaching purpose.

Participation of Muslim girls in virtual classes

Participation of girls were described as 30-40% in the online class, stating the inaccessibility of the mobile phones. Some parents could not afford an additional mobile phone which can be kept at home for the online teaching learning. Some girls shared that they do not have a separate room in their house, wherein they can sit and attend their class-thus because of the surrounding disturbances, they were not attending the online classes. Thus, it can be inferred that in this school as well the academic performance of the Muslim girls was affected.

School -C

Towards the North direction of the city area, School C is conducting the online classes in adopting three different ways: a) Through What's App group b) Through Google Meet c) Through You Tube Videos.

Challenges faced by schools in conducting virtual classes

It was described that the teachers began by using Google Meet application, but the outcome was not productive as the participation of the students were minimal, as the student population comprises of lower- and middle-income group families, hence there was inaccessibility of phones with students both with boys and girls studying in the school. Dealing to resolve this issue, the school authorities instructed school teachers to make short videos and post them in the What's-app group, so created as per respective subjects.

Another alternative the schools were given the task of uploading the videos on the official YouTube channel, so that the children can download the videos as per their time and space.

The school authorities also suggested giving hard copy of the assignment as another alternative for those students who were unable to use any of the above alternative. Herein, children were called up of course- with strict instruction of not coming in groups and collect their assignment copies from their subject teachers.

The authorities also reported, that the expenses of the stationery and other related expenses are borne by the school authorities from the Zakat fund- The Fund that is collected by the Muslim trust/ organizations during the holy month of Ramzaan.

Participation of Muslim girls in virtual classes

With special focus on girl's participation, 36-40% of girl's participation was noted, the reasons shared was the responsibilities at the domestic front, sibling care as well as the inaccessibility to the smart phones/ technological gadgets at home. Since, majority of the student population were from the lower- and middle-income group families, the non affordability was also a contributing reason hampering the educational advancement of the Muslim girls in the school, irrespective of the tremendous effort put in by the school authorities- to an extent of reducing the burden of stationery expenses from the students and managing from the available funds.

School-D

Challenges faced by schools in conducting virtual classes

School D, a private school, towards the North direction in Vadodara city. The teachers of the school described that like other schools, the school also has initiated online teaching learning, but the school authorities started receiving complaints from the parents and the students. Students were not able to participate in the class, due to lack of facilities at their end. There were many complaints received from the parents, stating that they have more than two or three children studying and since all the classes are conducted online, parents are not able to afford the cost of new smart phone or even the internet connection as well. It was stated that the school is struggling with the online teaching methodologies and the teachers are also not satisfied with the approach adopted. About the participation of students, there was nearly 10-15% of students participating in the classes. After the detection Covid-19 cases, the school teachers were also hesitant to come to school and the school had declared work from home for teachers as well.

Participation of Muslim girls in virtual classes

On taking responses from girls, most of the girls shared that they have the younger siblings studying, and in order to help their younger siblings and to facilitate then in attending their own virtual classes, they had to forego their own class schedules. Some girls responded that because of the financial scarcity in the family, parents are not able to make internet facilities.

School- E

The School E caters to student population from middle and upper middle-income group families. It was specified that the school had initiated online classes from the month of April 2020. Along with the online classes, the teachers were also engaged in one- to one counselling to students of the school telephonically and through Zoom application. To ensure, the educational status of students, online meeting was conducted with parents.

Challenges faced by schools in conducting virtual classes

Like other schools, this school has also faced challenge wherein parents have complaint that they are not able to afford an android phone and the internet data for their children, as they have more than two to three children studying. Another challenge faced by the authorities that students living in joint families do not have a separate area for their online classes, and hence cannot purely concentrate in the classes.

Participation of Muslim girls in virtual classes

Particularly focusing on girl's participation, it was stated that 95% of the girls were having access to technological facilities and were able to use it conveniently. They shared that the they were regular in attending their virtual classes and was very suitably able to handle the online classes. This shows that in this school, the Muslim girls were able to participate regularly in the online classes, whereas, some girls shared that the only problem that they face is lack of separate space for attending the online classes in their house.

School- F

The School F, situated in a sub-urban locality in the western part of the Vadodara city, also had initiated the academic classes through Zoom application.

Challenges faced by schools in conducting virtual classes

Deriving the response from this school also encountered similar problems of not having access to smartphones for children and hence the teachers, then adopted What's App option, where they recorded their videos and send it to all the students of their classes.

Participation of Muslim girls in virtual classes

This school had also witnessed less participation from the girls of about 5-10 %, as majority of the girls did not have access to mobile phones with them.

School- G

School G, in the west direction of Vadodara city, manages its online classes of secondary and higher secondary classes from standard IX to XII and send the PDF documents to the parents of the students of the primary classes.

Challenges faced by schools in conducting virtual classes

The school authorities have also received complaints from parents to not conduct online classes and to adopt some other mechanism. Parents are unable to afford the phones and the internet data packs for the children, as there are 2-3 children studying in the school. It is difficult for them to manage with the schedule of the online classes, especially in case of family with more than one child. Teachers were also trained for conducting classes, but for the trust it is also difficult to carry out the salary expenses of the teachers, as the school cannot ask for fees from the students.

Participation of Muslim girls in virtual classes

Participation of girls in online classes is less, because of domestic responsibilities as one reason, and in cases where there are younger siblings, and because of lack of access to technology by parents, the girls at the cost of missing their classes, help their younger siblings.

School- H

Challenges faced by schools in conducting virtual classes

The School H, in the rural area of Vadodara city has not yet began with online classes as student's population are not having access to the smart phones and the teachers are also not acquainted with online teaching methods. The school distributes teaching pamphlets to the students and gradually some teachers send video recording through the What's App group to the students, yet they have not started with online teaching classes.

Participation of Muslim girls in virtual classes

On deriving the reviews, it was found that, since majority of the girls from the rural areas, there were internet connectivity issues. Hence the school did not conductany online classes, but with the study materials distributed by the school and the girls pursued their studies.

School-I

School I, in rural locality of Vadodara, is managing its online classes during Covid- 19 period by sending videos through What's App group for the primary section, created separately for boys and girls according to their classes. For secondary classes, Google meet application is used by the teachers for conducting the online classes. For the Higher Secondary classes, YouTube is used and the link for the same is shared to the students through their What's App group.

Challenges faced by schools in conducting virtual classes

Irrespective of various mediums adopted for the different classes, it was narrated that the teachers and the management are also facing challenges as the students especially girls are not techno savvy and there is always a disturbance in classes as there is low internet connectivity in the village. There are also students whose parents cannot afford the electronic accessories; hence it is difficult for the authorities to meet with the individual differences. With specific emphasis on participation of students, it was stated students who have access to technological facilities, do participate in the classes and are able to utilize it effectively.

Participation of Muslim girls in virtual classes

On taking reviews of Muslim girls, pertaining to the participation of in virtual classes, majority of the girls shared that they were not able to attend the online classes as they do not have access to smart phones and there is always an internet connectivity issue in the village, hence the process of virtual classes was not having smooth process, resulting in less participation of Muslim girls.

School- J

The School J, in rural region of Vadodara city, also runs the online classes through What's App group and You tube for the higher secondary classes.

Challenges faced by schools in conducting virtual classes

Particularly for the challenges faced, it was stated that the during the lockdown phase, there was no income for some families, and it was difficult for parents to afford the smartphones and the internet data packs. Thus, majority of children were not able to attend the online classes. The teachers also have taken up counselling facilities with the parents of the girl students studying in higher secondary classes, as the girls' participation is less due to increase in responsibilities at domestic front. But because of the non affordability of the parents, there was no consistency or scheduled followed in the virtual classes, the students were using government of Gujarat telecast on DD Girnar for studying various concepts.

Participation of Muslim girls in virtual classes

From the review, it was observed that majority of girls pursued their education from the telecast on DD Girnar and no online sessions were undertaken by the schools.

Comparative view of all the Schools Chosen for the Study

No	Type of School	Approach adopted	Challenges encountered
1	Government	Recording of videos by teachers and sharing on the What's App of children, so that they can watch the videos when phone is accessible	1) Lack of smartphones at home, phone is with parents and unaffordability of parents. 2) Because of the lack of availability of the smart phones at home, due to lack of income of the parents to afford a distinct phone for the education of girls, and responsibility of the domestic work, girls were not regular in their virtual classes, which has affected their education.
2	Government	Zoom application for secondary and Higher	Teachers were not trained for online teaching.

		Secondary classes	30-40% girls participated in online classes. Inaccessibility of mobile phones with girls Lack of separate space for attending classes
3	Government	Through What's App Through Google Meet Uploading YouTube videos Hard copies of the assignments	36-40% girls participated in online classes. Inaccessibility and unaffordability of mobile phones
4	Private	Online classes	Parents complaint lack of mobile phones, as there are more than two children in the families and cannot afford to have new phone for the classes. Financial scarcity, sibling care and domestic responsibilities
5	Private	Online classes	Many complaints by parents for not being able to afford phone for each child in case of more than 2 children Girls living in joint families were not getting a

			separate space for their online classes.
6	Private	Online classes	5-10% of girls' participation, majority of girls did not have access to the smart phones
7	Private	Online classes	Complaints by parents for not being able to afford phone for each child in case of more than 2 children. Participation of girls is less, to help their younger siblings in their online classes and missing their own.
8	Private	No online classes Distributing study materials	Lack of access of mobile phones.
9	Aided	What's App videos	Lack of mobile phones and low internet connectivity
10	Private	What's App videos	Lack of mobile phones at home. Participation of girls is limited due to domestic responsibilities.

Table 1: Comparative view of Schools under study

Findings of the Study:

Findings related to the Schools:

- From the findings of the 10 schools of Vadodara city, chosen for the study, it can be said that all the schools, whether private or government has adopted different online teaching methodologies.
- Another applicable finding that the paper suggests that some of the schools were not properly well equipped with the technological facilities- hence the teachers had to use their own internet plans to conduct the virtual classes, this finding is in support with the study done by Islam and Midya[10]explaining that meagre infrastructural amenities within the schools are accumulating lower academic performance of the students.
- Widely, the schools chosen for the study were facing the principal challenge that is lack of student's participation in virtual classes due to loss of income of parents wherein parents are not able to afford the android phones and the expenses of the internet data packs.
- The response derived from the school authorities show that the school authorities have tried various measures, for the continuation of the academics, yet are facing challenges in organizing and getting maximum students participation in virtual classes.
- The paper also suggests that there was only one private school, out of all the schools chosen for the study, which were able to fetch optimum participation in virtual classes from all students including girls and were able to manage efficiently their academics in online classes.
- The school authorities are also very much aware and are concerned about the girls studying in higher secondary classes, and hence, they have adopted counselling services for the parents and for the girls themselves so as to retain these girls in schools.

Findings related to Muslim girls of Higher Secondary Classes.

- The responses from the Muslim girls, show that in majority of the schools covered under the study, participation of girls in online classes is less, because of increase in responsibilities in household and sibling's care.

- The responses derived from the 30 Muslim girls studying in Higher Secondary classes indicates that the students are not having access to or are not able to utilize the online teaching methodologies, which is affecting their overall performance.
- From the reply of Muslim girls interviewed for the purpose of the study, it can be said that these girls were not satisfied with this entire process of virtual classes, as they are unable to concentrate during their classes, which has its impact in their subject clarity.

Conclusion

- The findings of the study reflect lesser participation of Muslim girls in the online classes due to reasons like reduce of family income because of prolonged lockdown and hence parents are not able to afford the digital platform for education. As noted in many cases, the number of children is more in the family and thus it becomes very difficult to manage the online classes as they cannot afford to have the gadgets to facilitate the children's education. In majority of the cases, it is also seen that the girls are more pressurized of managing the household chores at home and at the same time helping their younger siblings in their online classes, and thus they miss out their own classes.
- The previous researches undertaken in the area of education of Muslim girls points that the educational progress among the Muslim community is lower, the magnitude of which has seen to an increase level from the findings of the paper during this Covid-19 pandemic situations.
- Amidst this situation, it is very important to advocate as well as to do counselling to the parents pertaining to the girl child education by the teachers, the school authorities, the educationist from the community, so as to reduce the number of girl's dropout from the schools. Simultaneously the school authorities, the community activists, the educationist should identify and try to help such families by supporting them financially from the Zakat funds that they cater to in the holy month of Ramzaan, because keeping girls in schools is equally important as spreading awareness on health and hygiene and to prevent the spread of Covid-19.

Acknowledgement

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Annexure-I

Dear Sir/ Madam,

Request you to provide me with following details as the researcher is writing an academic paper on. Muslim Girl's Education in COVID-19 times: Few Case Studies from Vadodara. To assure you, all the information will be used only for the academic purpose only.

1) What measures are taken by the school authorities to support the education of girls studying in higher secondary classes during COVID-19?

2) What are the challenges faced to support education of girls studying in higher secondary classes during COVID-19?

3) Are these girls having access to the technological facilities? If yes, are they able to utilize these facilities?

4) Your Suggestions/ remarks/ observation that could be of help for the researcher. (You can also share few of your experience)

A Study of Value Inculcation Practices for Secondary School Students

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Abstract

India is rich in cultural heritage and is a country with an ancient civilization so well known for its well defined system of education. Education is perceived as a means of ensuring the future well-being of student's according to Professor Fancy education as the processes of remarking experience, giving it a more socialized value through increased individual experience, by giving the individual better control over his powers. Value education must be integral to the whole process of education and can't be imparted as a separate bit of education; the whole education should be value oriented. The purpose of value education is to develop integrated and balanced personality. Values are not born in nature. They are acquired and inculcated. Education is closely associated with values and must develop in learners' caring, co-operation and respect for one another. Our educational policies and the curriculum framework all along have emphasized the need for value education co-curricular activities play a very important role for inculcation of values in the school students. In this research paper researcher discusses about how value inculcation practices done by school teachers through co-curricular activities among the school students.

Key words: Inculcation values, value education, co-curricular activities.

Introduction

The purpose of value inculcation is to develop all round personality development of the students. Values are acquired and imparted.[1] The family, its atmosphere and traditions, Sanskara along with humanitarianism play a very important role in value inculcation in our

students and us. The National Policy on Education (NPE 1986) states: that education as an organized social system and an important function in the development of moral values, spiritual values and aesthetic values, and nobody can deny that teachers have a very crucial role to play in the achievement of this objective.[2]

We can inculcate values in our students in various ways. In the beginning, very simple human values like love, truth, peace, and punctuality can be introduced among the students.[3] These values can be practiced in the classroom through curricular and co-curricular activities. Co-curricular activities employ a vital place in teacher education. Education is essential for all round development of a child. Education has always been integrated with society. It has both a personal and social dimension, they are inseparable.[4] Gujarat Secondary and higher secondary education board too introduced the CCE/SCE. One of the main aims of SCE is to evaluate scholastic and co-scholastic proficiency. Co-scholastic proficiencies include life skill, attitudes and values, literary and creative skills, scientific temperament, aesthetic skill, performing art, and sports.[5]

The present Study is an attempt to study value inculcation practices for adolescents in government secondary schools in Aspirational districts of Gujarat**.**

What is Value Inculcation?

Fixing up of values in mind is value inculcation approaches of value inculcation are:

- Direct approach- inculcated through curriculum and class room instruction.
- Indirect approach- inculcated through co-curricular activities plays, movies, telling stories, dramas, cultural activities and incidents.
- Incidental approach is the most effective approach.
- A person inculcates certain values through his/her real life experiences.
- Inculcation of values happens incidentally.[6]

Value Inculcation Practices

Co-curricular activities are very important sources of values inculcation. These activities, often voluntary, are taken up with involved participation and are therefore highly refreshing and creative. The informality and openness generated by these activities help the child to come in close contact with the teachers and their peer group several times, and it just creates the healthy and natural environment for inculcation of values among learners.[7-8]

The inclusion of co-curricular activities in teaching learning process is such that it is possible through them to effectively achieve physical, intellectual, emotional wellbeing and ethical integration's-curricular activities, is based on activities, provide maximum participation among students. The atmosphere played a very vital role and helps in learning experiences in a creative manner.[9-10]

Co-curricular activities are to be organized in different ways, e.g., in the classroom, in the school as well as in outside of the classroom activities. Classroom is a small organization of the school in a larger school perspective. It provides the opportunity of its all members to grow. A lot of value practices for inculcation of values among students can take place. Personal attachment, charisma and the body language of a class teacher can effectively isolate the class from many negative influences.[11-12]

About Aspirational Districts

The Government of India has launched the 'Transformation of Aspirational Districts' initiative in January, 2018 in 117 districts with a vision of a New India by 2022 by improving India's ranking under human development index, raising living standards and ensuring inclusive growth of all its citizens. The identified districts are eligible for enhanced funding and priority allocation of various initiatives undertaken by the department and ministry. The three critical components of the programme are convergence (of Central & State Schemes), Collaboration (of Central, State level 'Prabhari' Officers & District Collectors) and Competition among districts driven by a mass movement.[13]

ADP focuses on five main themes – Health & Nutrition, Education, Agriculture & Water Resources, Financial Inclusion & Skill Development, and Basic Infrastructure. These five identified thematic areas are further broken down into 49 indicators. The reason why the programme includes these particular themes is that they directly impact the quality of life as well as the economic productivity of citizens. The salient feature of this programme is that NITI Aayog in collaboration with the Planning Department.[13]

Selection Criteria for Aspirational Districts

Health & Nutrition, Education, Agriculture & Water Resources, Financial Inclusion & Skill Development and Basic Infrastructure have been identified as core areas of focus of this programme. Each of the above focus areas have been represented through 11core indicators

and measurable outcomes. Weight ages too have been accorded to these areas at 30% for Health & Nutrition, 30% for Education, 20% for Agriculture and Water Resources, 10% for Financial Inclusion and 10% for Skill Development and Basic Infrastructure. A composite index was arrived at considering the above mentioned indicators and the districts were ranked based on it. This exercise resulted in identification of 117 Aspirational Districts which had huge potential for transformation and had somehow missed the fruits of equitable and homogenous development work.[13]

The education sector focuses on *learning outcomes* (transition rate from primary to upper primary, and subsequently to secondary schooling, average scores in mathematics and languages and so on) as well as infrastructural (toilet access for girls, electricity supply, drinking water, etc.) and institutional indicators (pupil teacher ratio, timely delivery of textbooks, etc.). Considering the importance of education in enabling development, it commands a weight age of 30 percent – similar to that of health. Unlike health, none of the districts have managed to achieve their set targets on an average in the education sector. All of the Tier 1 districts, however, were merely 5 to 10 percent away from their respective targets over the last year.

The Aspirational Districts programme (ADP) and Sustainable Development Goals (SDGs) both emphasize on the provisioning of basic services through sustainable means to the most marginalized communities and people. As discussed earlier, the focus of ADP revolves around six domains: • Health • Education • Agriculture and Water Resources • Skill Development • Financial Inclusion • Basic Infrastructure

The Aspirational districts programme aims to improve the socio-economic status of various districts, selected by the central government across states. After the National Achievement Survey's startling results, Prime Minister Narendra Modi had chosen 117 districts and declared eight indicators. Out of these 117 districts, Gujarat's Narmada and Dahod were selected. In the June report, Dahod emerged as the top district among 117, whereas Narmada was ranked thirteen.[13]

Objectives

The study is based on below objectives:

1. To identify the values associated with the activities conducted in secondary schools of Aspirational districts of Gujarat.
2. To study the strategies followed in secondary school of Aspirational districts of Gujarat for inculcation of values
3. To find the effectiveness of various strategies follows for inculcation of values among secondary school adolescents of Aspirational districts of Gujarat.
4. To suggest innovative strategies for value inculcation among secondary school adolescents as perceived by the teachers and academic leader /experts.

Research questions

The following research questions were proposed to achieve the objectives of the study:

1. What type of values is associated with the co-curricular activities conducted in the school students?

2. What are the strategies followed to inculcate values through co-curricular activities and how effective are they?

Results and Discussion

Mode of Value Inculcation in the classroom by teachers				
Classroom Activities	**YES**	**%**	**NO**	**%**
1. Through Drama	45	90	5	10
2. Role play/folk dance	48	96	2	4
3. Through Poster Competition	33	66	17	34
4. Expert Talk	2	4	48	96
5. Value Clarification	18	36	32	64

Table 1: Mode of Value inculcation in classroom by teachers

From the table no. 1, the mode of value inculcation in the classroom by teachers was found – teachers were conducted

- drama/mono acting
- Role play/folk dance,
- Poster competition,
- Organized special talk on special days

- Conducted case studies/ situation analysis for value clarification to inculcate values among adolescents in government secondary schools.

Value Imparting in the classroom by teachers				
Classroom Activities	**YES**	**%**	**NO**	**%**
1. Checking the personal cleanliness of students from time to time	46	92	4	8
2. Involving children in maintaining cleanliness in classrooms and school surroundings	44	88	6	12
3. Encouraging good eating habits in school and at home	33	66	17	34
4. Greeting Teachers when he/she enters the classroom	12	24	38	76
5. Stand while talking to teachers	36	72	14	28
6. Involve children in maintaining cleanliness of the campus	41	82	9	18
7. Story telling	38	76	12	24
8. Dramatization	23	46	27	54
9. Scouting ,Guiding	26	52	24	48
10. Adventure clubs	17	34	33	66
11. Yoga, meditation	46	92	4	8
12. Patriotic songs	26	52	24	48
13. Explaining rules and regulations of school discipline	5	10	45	90

Table 2: Inculcating Values in classroom through various classroom activities by teachers

From above table no.2, it can be said that ninety-two percent of the teachers were of the belief that checking personal cleanliness of students from time to time and yoga, meditation were effective classroom activities for imparting values. Seventy-six percent of teachers responded that story telling was also effective activity for inculcation of values among adolescents; while fifty-two percent of the teachers opined that activities, like encouraging good eating habits in school and at home, were found very effective for inculcation of values in the classroom.

Value Imparting in the classroom by teachers				
Classroom Activities	**YES**	**%**	**NO**	**%**
1. Debate and discussions	36	72	14	56
2. Celebration of different religious festivals	44	88	6	12
3. Sports and games	33	66	17	34
4. Cultural Programs	12	24	38	76
5. Prayer Assembly	48	96	2	4
6. Shramdaan	11	22	39	78
7. Social service	38	76	12	24
8. Celebrations of birthdays of great men	23	46	27	54
9. Participatory programs	26	52	24	48
10. Anti-illiteracy drives	7	14	43	86
11. Campaigns against diseases	15	30	35	70
12. Seminars, workshops	16	32	24	68
13. Field visits	44	88	6	12

Table 3: Inculcating Values in classroom through various classroom activities by teachers

From above table no.3, it can be said that ninety-six percent of the teachers were of the belief that prayer assembly is effective classroom activity for imparting values. Eighty-eight percent of teachers responded that celebration of different religious festivals were also effective activity for inculcation of values among adolescence. While seventy-two percent of the teachers opined that activities like debate and discussion for inculcation of values in the classroom were very effective. While sixty-six percent of the teachers opined that activity like competitions on sport and games were also good for imparting value inculcation in the classroom.

Major findings

1. Ninety-two percent of the teachers were of the belief that checking personal cleanliness of students from time to time and yoga, meditation were effective classroom activities for imparting values.
2. Seventy-six percent of teachers responded that story telling was also effective activity for inculcation of values among adolescents.

3. Fifty-two percent of the teachers opined that activities, like encouraging good eating habits in school and at home, were found very effective for inculcation of values in the classroom.
4. Seventy-two percent of the teachers opined that activities like debate and discussion for inculcation of values in the classroom were very effective.
5. Sixty-six percent of the teachers opined that activity like competitions on sport and games were also good for imparting value inculcation in the classroom.
6. Eighty-eight percent of teachers responded that celebration of different religious festivals were also effective activity for inculcation of values among adolescence.
7. Total twenty values associated in different classroom activities (total 18 activities) practiced by teachers in classroom were found.

Suggestions for schools for inculcating values among the School Students

The following initiatives, activities and programmes should be organized in the school to inculcate the values among the school students, so that they can apply these values to their real life situation.

1. All the teachers should act as role models to the students in practicing environmental values.
2. Awareness programmes should be organized on health and environment and population education.
3. The community and social issues should be brought to the notice of all the students to develop awareness among them.
4. The physical and health education should be given due importance.
5. Community singing programmes, national integration camps, the NSS, NCC, and Scouts and Guides activities should be organized.
6. Work experience and SUPW activities develop a positive value towards the work culture, dignity of labour and the proper utilization of the leisure time- these should be given due importance.
7. Arrange school sanitation drive or activities.
8. Arrange different kinds of co-curricular activities, like world environment day, world health day. etc.

Following Values are inculcated through appropriate activities by teachers		
No.	**Activities**	**Name of Values associated**
1	Prayer Assembly	cooperation, honesty, punctuality
2	Celebration of National Festivals	national integration
3	Thought of the Day	simplicity, honesty, punctuality
4	Celebration of Environmental Day	save tree, protection of environment
5	Educational Visit	cooperation, national integrity
6	Van Mahotsav	save tree, protection of environment
7	Drawing Competition	discrimination of right or wrong
8	Sports Meets	sportsmanship's, cooperation
9	Cultural Program	kindness
10	Checking the personal cleanliness of students	cleanliness and hygiene
11	Involving children in maintaining cleanliness in classrooms and school surroundings	cleanliness and hygiene
12	Encouraging good eating habits in school and at home.	cleanliness and hygiene
13	telling stories	truthfulness
14	Explaining rules and regulations of school discipline	obedience
15	Voluntary services during functions	faithfulness
16	Scouting, guiding, adventure clubs	courage, services to others
17	Interest to do work in time	sense of duty and responsibility
18	Debates and discussions	discrimination of right or wrong

Table 4: Values inculcation through activities

Total twenty (20) values associated in different classroom activities (total 18 activities) practiced by teachers in classroom were found. Through these classroom activities teacher can impart values among students.

Conclusions

The values present a true perspective of the development of any society or nation. They tell us to what extent a society or nation has developed itself. But today we are facing the problem of value degeneration. According to Reddy the main causes of value degeneration

are – lack of respect of human life, lack of respect for authority, rules and regulations, crime and corruption, abuse of alcohol and drugs, abuse of women and children. We know that today's children are tomorrow's citizens. Education through activities co-curricular activities can be the solution for all types of the problems. The main purpose of the present study is to see what value inculcation practices are held in school for providing value education and to study the perception of the teachers about the value education programs, so that a comprehensive idea of value education program can be known. Based on co-curricular activities, a teacher has to make suitable, appropriate time table to transact for those activities, motivate learner's participation in the class. Then these activities will have a wholesome effect and have very important educational values too. All the co-curricular activities should be organized with a commitment and devotion. Planning a logical programme based on different activities will strengthen abilities of self-expression, preparation for vocation, sentiment of loyalty, organizing ability, creativity, and constructiveness and maintain good relation between school and community.

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Fabrication of AA 6351 + 5% SiC Composite using Stir Casting Process

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Abstract

Present article attempts to fabricate Aluminum Matrix Composites(AMC) using stir casting process. The matrix phase of composite consists of commercially available AA 6351 whereas the reinforcement phase will be of Silicon Carbide (SiC). The distribution of reinforcement particles within matrix, presence of any casting defects, agglomeration of reinforcement particles and other characteristics of fabricated composites has been investigated using Optical Microscope (OM) and Scanning Electron Microscope (SEM). The results of microstructure investigation revealed homogenous distribution of SiC particles within aluminum matrix with some particle free region. Apart from this, article also discusses about measured hardness of fabricated composites.

Keywords

Metal Matrix Composite, Aluminum Matrix Composites, Stir Casting, Microstructure, Silicon Carbide (SiC)

Introduction

Owing to the research and development in last few decades, Metal Matrix Composites (MMC) has been identified as advanced material which has capability to replace the conventional materials[1]. Broadly, it can be said that MMC fulfills several needs of industries such as transportation, aerospace, aircraft, electronics, electrical power transmission and automobile. For instance, in F – 16 aircraft, the doors made up of aluminum are now being replaced with silicon carbide (SiC) reinforced MMC and by doing so, enhancement in fatigue life was

observed[2]. Apart from this, that MMC are used for fabrication of bicycle frames, diesel engine pistons, engine shaft, piston crown, components of brake, connecting rod, piston rings, cylinder liners, bearings, engine blocks, super conductors, and many more components[2-4].Due to several characteristics such as superior mechanical properties, higher strength, lower density, stable mechanical properties even at elevated temperature, better thermal properties, lower coefficient of thermal expansion, higher stiffness, better dimensional stability and many more, MMC have gained popularity in aforementioned industrial sectors[5-7]. Among several derivatives of MMC, particulate reinforced metal matrix composite finds wider application in engineering world[4]. In particulate metal matrix composites, light metals/alloys such as aluminum, magnesium, titanium, copper and many more acts as matrix phase whereas, particles of oxides, carbides, ceramics, organic compounds act as reinforcement phase[5, 8]. Among various combination of matrix and reinforcement, aluminum matrix reinforced with ceramic particles have been considered for present investigation. There exist several fabrication techniques such as centrifugal casting, squeeze casting, in-situ casting, powder metallurgy, diffusion bonding process and stir casting process using which bulk/volume MMC can be fabricated[9-13]. However, Brains et al.[14] and Taha[15]from their study reported stir casting process as simple, cost effect and comparatively cheaper procedure available for fabrication of MMC/AMC. Apart from this, it was also reported that stir casting process has capability of fabricating composites with complex shape without much constraints.

Surappa[16] and Soltani et al.[17] reported stir casting process to be better in every aspect and industries can implement the same for fabrication of MMC. Lee et al.[18] investigated the interfacial reaction occurred during fabrication of B_4C/AA 6061 using stir casting process. It was reported that interface of B_4C/Al showed presence of Al_4C_3/Ti, chromium diboride, magnesium oxide and TiB_2 precipitates. However, the interface didn't revealed presence of any deleterious precipitates such as AlB_2 or Al_3B_4.It should be noted that these deleterious precipitates formed in composites adversely affect the mechanical properties. Yu et al.[13] developed a stir casting route to fabricated large scale AA6061 + 31% B_4C composites and investigated the effect of process parameters on microstructure and mechanical properties of fabricated composites. For successful fabrication of AMC, vacuum stirring, reinforcement particles feeding and ingots cooling were the dominating criteria. Results of Scanning Electron Microscopy (SEM) and X-ray Diffraction (XRD) revealed presence of B_4Cparticleswhich were embedded and homogenously distributed in aluminum matrix. Along with this, presence of

Mg_2Si was also reported. On comparing the tensile strength of AA 6061 + 31%B_4C with AA 1100 + 31%B_4C, enhancement in tensile strength by 112.5% was observed for AA 6061 + 31%B_4C composites due to higher strength of matrix. Rajendran and Suresh[19] fabricated hybrid composites in which aluminum alloys were reinforced with Silicon Carbide (SiC) and fly ash. Considering different weight fraction of SiC and fly ash, six different combination of AMC was fabricated. Due to variation in weight fraction of SiC and fly ash, different composition revealed variation in grain size and distribution of reinforcement particles. However, aluminum alloy reinforced with 10% SiC and 10% fly ash revealed proper grain growth with homogenously distributed SiC particles. Due to the same, enhancement in mechanical properties was reported. For all fabricated composites, thermal conductivity was found to be higher than 400 W/m.K, which was also matching the value required for engine block. Similarly, there exist several articles related to fabrication and characterization of stir cast AMC[20-22].

Present article focuses on fabrication of mono AMC using stir casting process. The article discusses about the fabrication procedure adopted for fabrication of AA 6351 reinforced with 5% weight fraction of SiC. The presence and distribution of SiC particles was observed using Optical Microscopy (OM) and SEM. Along with microstructural studies, hardness of fabricated composites was also investigated.

Experimental

Stir casting route was considered for fabrication of AMC. Experimental setup of stir casting process majorly consist of two components i.e. furnace and stirrer. Furnace used for melting matrix material is shown in figure 1. For the matrix material commercially available AA 6531 rods having 25.4 mm in diameter and 1000 mm in length has been considered. The chemical composition of AA 6351 is represented in table 1. For present study, AA 6531 matrix was reinforced with 5 % weight fraction of SiC having particles size of 100-120 μm.

Figure 1: Electrical Furnace used for melting matrix material

Elements	Si	Mg	Mn	Fe	Zn	Ti	Cu	Cr	Al
Amount (%)	1.2	0.67	0.58	0.5	0.2	0.2	0.1	0.05	Remaining

Table 1: Chemical Composition of AA 6351-T6

For fabrication of AA 6351 + 5% SiC, rod of AA 6351 was cut into small pieces, each having length of 100 mm approximately. Cut pieces of matrix weighted and a batch of 1000 was formed. Similarly, reinforcement particles were weight as per the weight fraction of reinforcement to be incorporated in matrix material i.e. 50 g. Figure 2 represents the batch of aluminum matrix and corresponding reinforcement particles. Before melting, the electric furnace was preheated to 180 °C and then the crucible consisting of matrix was inserted in furnace. The aluminum matrix was then heated up to 780 °C, which is higher than the melting point of aluminum. On successful melting, the molten matrix was stir in a manner such that vortex was created. In the meantime, SiC particles were preheated to 350 °C for 15 minutes and were added to the vortex created in molten aluminum. Along with SiC particles, 1 % of magnesium was also added to molten matrix. Addition of magnesium acts as wetting agent between matrix and reinforcement and thus improved the wettability. Wettability enables the molten aluminum matrix to maintain the contact with solid surface of SiC particles. The molten mixture was stir for 5 minutes at stirring speed of 300 rpm, as represented in figure 3. The stirrer was having 4 blades and angle between two blades were 60°. After stirring, slag formed on the top surface was removed and the molten mixture was poured into mould. Design of

mould was such that the solidified cast component will have dimension of 100 × 100 × 10. On solidification, cast component was removed from mould.

Figure 2: Aluminium alloy and SiC particles as per weight fraction

Figure 3: Stirring of molten composite

Microstructural characteristics of fabricated composites were investigated using OM and SEM. The specimen required for each investigation was cut from fabricated and polished as per standard metallurgical procedure. For etching, Keller's reagent was prepared by mixing distilled water, nitric acid, hydrochloric acid and hydrofluoric acid in proportionate quantity. Keller's reagent was then applied on polished surface of specimen at room temperature and was dried out before microstructure examination.

Results and Discussion

To understand the distribution of reinforcement particles in aluminum matrix, microstructural investigation of fabricated AA 6351 + 5% SiC was performed. Figure 4 represents micrograph image obtained using OM. In the micrograph, the rounded black spots embedded in aluminum matrix represent SiC particles. It can be observed that those SiC particles are uniformly distributed within the matrix of aluminum. The preheating of reinforcement particles has proven beneficial and due to the same, reinforcement particles were found to embed within aluminum matrix. The preheating of SiC particles not only helps in removing the moisture from

reinforcement particles but also avoids the thermal mismatch between molten aluminum and SiC particles. Also, the addition of SiC particles directly into vortex formed in molten matrix has proven beneficial towards homogenous distribution of SiC. Additionally, addition of magnesium as wetting agent had helped in enhancing wettability between matrix and reinforcement. It has been reported that addition of wetting agent and preheating of reinforcement particles tends to remove impurities, desorption of gas, avoids settling of reinforcement particles and alters the surface composition due to formation of oxide layer on surface[23].

Figure 4 represents dendritic like structure which were formed during solidification phase. Aluminum alloys are known for higher cooling rate and provides enough undercooling. This undercooling will increase nucleation site with reduction in dendritic arm spacing. Small nuclei formed during nucleation will mechanically block each other during growth process and thus results in fine and uniform dendritic structure. On higher magnification, as represented in figure 5 it was observed along with SiC, the fabricated composites were found to have Mg_2Si and Al-Mg-Si phase. The thin, black and needle shape phase in microstructure represents Mg_2Si. These Mg_2Si phase were observed near Al/SiC interface or were embedded in α-Al. Apart from this, slightly transparent phases present in microstructure of AA 6351 + 5% SiC represents ternary eutectic phase i.e. Al-Mg-Si. Similar observations were also reported by other researchers[24-26].

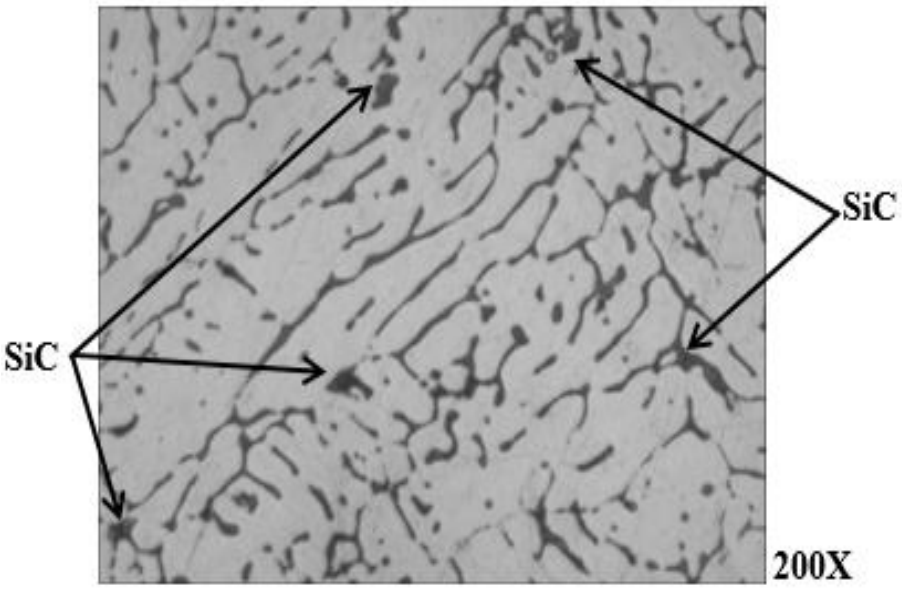

Figure 4: Optical Microscopy (OM) of AA 6351 + 5% SiC

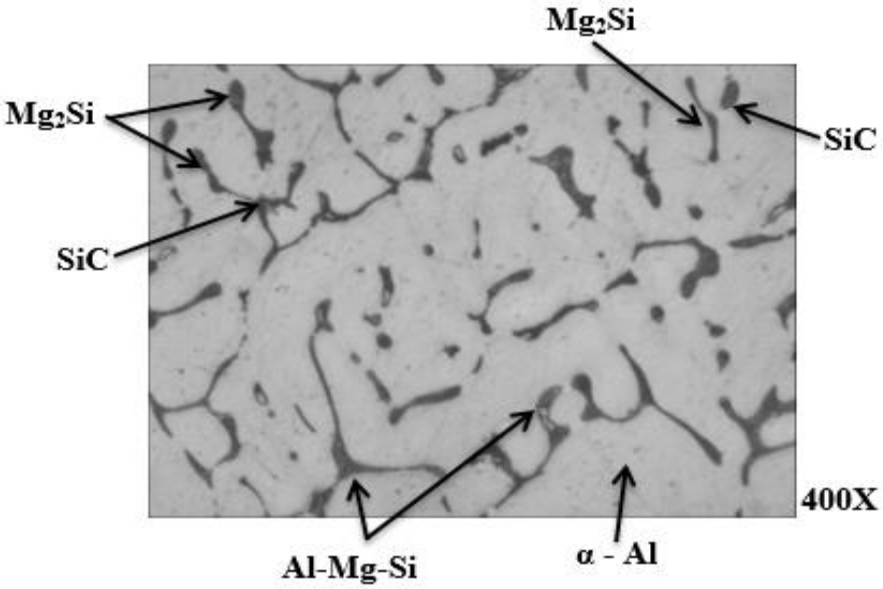

Figure 5: Presence of SiC, Mg_2Si and Al-Mg-Si in AA 6351 + 5% SiC observed using Optical Microscopy (OM)

Similar phases were reported from SEM images of AA 6351 + 5%SiC composites. Apart from this, SEM image represented in figure 6 also revealed few particles free region. Particle free regions can be observed due to lower weight fraction of reinforcement particles. Similar observation was also reported by Shabani et al.[27] and Raj and Thakur[28]. Raj and Thakur[28] also reported that increase in weight fraction of reinforcement particles reduces the particle deficient region and causes uniform/homogenous distribution of reinforcement particles. Figure 7 represents SEM images taken at higher magnification. Even at higher magnification, SEM micrographs of fabricated composites didn't reveal any presence of clusters/agglomeration of SiC particles. Earlier it has been reported that increase in weight fraction of reinforcement particles tends to generate few clusters/agglomeration of reinforcement particles. Due the stirring, reinforcement particles tends form clusters with matrix which is termed as agglomeration of reinforcement particles. Increase in weight fraction of reinforcement particles tends to increase the density difference which makes stirring difficult. This difficulty in stirring restricts the motion of reinforcement particles within molten matrix and thus results in agglomeration of reinforcement particles. Apart from this, SEM micrograph didn't reveal presence of any deleterious phase which affects mechanical properties of fabricated composites. The hardness test was conducted at a load of 62.5 Kg with a dwell period of 2.5

sec. Due to addition of SiC particles in AA 6351 alloy, enhancement in hardness of fabricated composite was observed. The measured hardness of AA 6351 was 54 HB and that of AA 6351 + 5% SiC was 61 HB. The ceramic particles are known for their hardness and thus addition of SiC particles in light weight alloys tends to enhance the final hardness of composites. Along with this, the enhancement in hardness was observed due to absence of any casting defects, agglomerated SiC particles and deleterious phase.

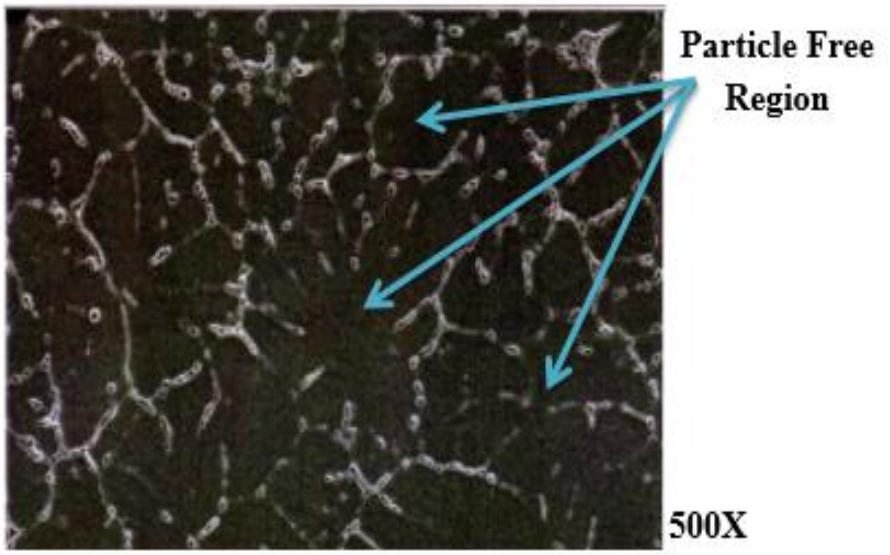

Figure 6 : SEM Micrograph of AA 6351 + 5% SiC

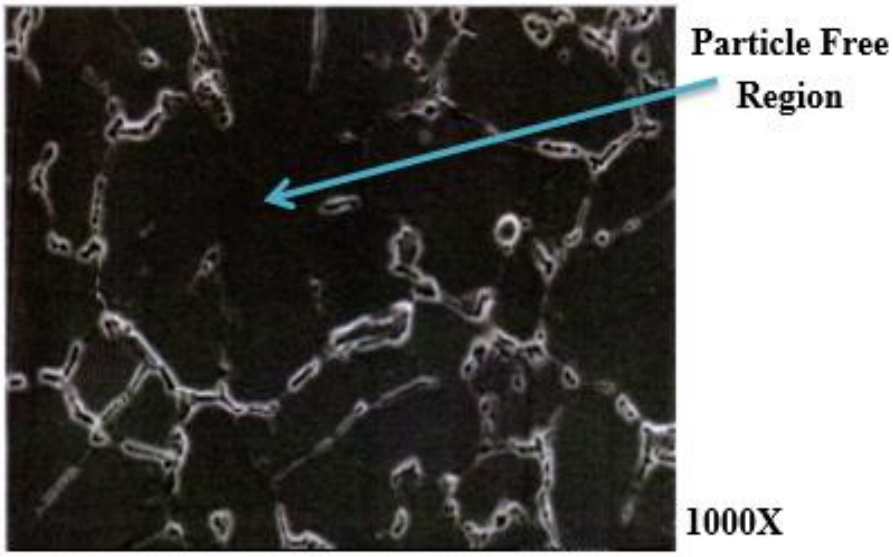

Figure 7 :Cluster free microstructure of AA 6351 + 5%SiC observed in SEM micrograph of AA 6351 + 5% SiC

Conclusion

The present study can be concluded as follows:

- Stir casting process possess potential to fabricate AMC with matrix of AA 6351 and reinforcement phase of Silicon Carbide (SiC). However, it becomes necessary to have control over several process parameters such as stirring speed, stirring time, stirring temperature and melting temperature of alloy.
- Optical Microscopy and Scanning Electron Microscopy reveled presence of SiC particles which were embedded in aluminum matrix. Owing to preheating of SiC particles and addition of magnesium as wetting agent, proper interfacial bonding between matrix and reinforcement along with homogenous distribution of reinforcement particles was reported. However, due to lower weight fraction of reinforcement particles, some particles free regions were observed.
- Enhancement in hardness of fabricated composite was observed due to addition of SiC particles and absence of agglomeration/clusters of reinforcement particles, presence of deleterious phase and casting defects such as void, grooves or tunnel defects

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Heavy Metals and their Effect on Mammalian Fertility

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Abstract

Heavy metals such as Lead, Mercury, Nickel, Chromium, Copper etc. are naturally occurring metals found in Earth's crust with high densities and are one of major pollutants. These metals are essential for all living organism in lesser quantities, exceeding its level may lead to toxicity. Some of the heavy metals are. These metals are released into environment either by industrial waste, agriculture runoff or fossil fuels combustion. These metals affect all the major organs in body causing toxicity. The range of toxicity depends upon factors such as dose, chemical species and route of exposure. These metals also lead to chronic reproductive toxicity causing impairments in gametogenesis by lowering the number of sperms or hampering the maturation of oocyte or egg, steroidogenesis by altering the levels of testosterone and estrogen and altering the reproductive tract functions by accumulating in the tissues and destroying the structure of tract. Prolonged exposure of these metals leads to infertility or subfertility. This paper summarizes the effect of heavy metals - (Nickel, Cadmium, Lead and Mercury) on the reproductive organs studied on mammalian model organisms.

Keywords

Heavy metals, Reproductive toxicity, infertility, subfertility.

Introduction

Environmental contaminants are chemicals, biological or radioactive waste which are released into environment and causes pollution. These contaminants are toxic to any living organism including humans. The most common sources of these contaminants are

combustion of fossil fuels, mining and mineral processing industries, households, forestry and agriculture and industrial production which lead to the release of heavy metals, volatile organic compounds, greenhouse gases, organochlorides etc[1].

Heavy metals are naturally occurring metals having high densities and are one of the major causes of environmental contaminant. The use of heavy metals has been increased with time and they are commonly used in industries, mining, smelting and thermal power plants. The most frequently found heavy metals at national and international levels are arsenic, cadmium, chromium, copper, lead, nickel and zinc[2]. These metals have a crucial role in biological functions of body as they play an important role in oxidation – reduction reaction and also are an important constituent for various enzymes[3]. The exposure of these metals can be either by inhalation, food chain or skin contact. The exposure of these metals affects the cellular organelles and its components such as mitochondria, cell membrane, nuclei, lyzosomes and endoplasmic reticulum. These metals also affect the enzymes which are involved in normal metabolism, damage repair and detoxification[4]. The metal ions interact with DNA and nuclear protein initiating DNA damage and conformational changes in the proteins which lead to cell cycle modulation, carcinogenesis or apoptosis. The basic mechanism involved in causing toxicity is the production of Reactive Oxygen Species (ROS). When the heavy metals attack the cells, there is an increase in ROS and the antioxidant enzymes. This increase results in oxidative stress which eventually leads to apoptosis. The heavy metals act on the nervous system causing inhibition of neurotransmitter and neuronal damage and thereby leading to neurotoxicity. Neurotoxicity is when the damage is done to the nervous system which alters the normal activity of system[3.] These metals also inactivate the regulatory molecules such as p53 and other transcription factors leading to carcinogenesis. Carcinogenesis is also caused when these heavy metals directly act on DNA repair mechanism by altering the enzymes structure and damaging the DNA due to generation of free radicals. When the free radicals generated due to these metals acts on the lipid membrane of cell, it leads to cell membrane damage which ultimately damages the cell. The action of free radicals on protein causes either inactivation of enzymes or protein misfolding, aggregation and conformational change in the end leading to loss of cellular function[3].

Reproduction is one of the important fundamental traits of all the living organisms. When any organism is subjected to the heavy metals exposure if often leads to reproductive toxicity. These metals hinder the basic functioning of the system by mimicking the ion, disrupting cell signaling pathways, oxidative stress, altering gene expression, apoptosis, disrupting testis – blood barrier, inflammation and endocrine disruption[5]. The toxicity also leads to infertility and subfertility. The couple is considered infertile when they cannot conceive naturally while subfertility is when there is a delay in conceiving. Infertility has become one of the prime problems in current scenario with an increase in number of population becoming infertile owing to environmental contaminants and current lifestyle[1]. According to World Health Organization (WHO), 1 in every 4 couple is infertile[6]. According to WHO, the common causes of infertility in male are semen ejaculatory problems, abnormal sperm morphology, count and motility while in female, the causes can be due to a range of abnormalities in ovaries, uterus, oviduct and hormone secretion[6].

This paper reviews the toxic effects of Nickel, Mercury, Cadmium and Lead on the mammalian fertility. These metals are the most commonly found heavy metals in the environment causing toxicity.

Heavy Metals and their association with Reproductive Toxicity

1. Nickel - Nickel is one of the essential metals for human body but when its concentration increases it becomes toxic to body. Nickel toxicity is a common in nickel ore smelting workers. It directly binds to DNA causing DNA damage and stimulating reactive oxygen species[7].

Impact on Rats

Nickel increases the level of circulating prolactin when a dose of 10 and 20mg/Kg $NiCl_2$ was given to male rats. Prolactin increases the luteinizing hormone receptors in leydig cells, to secrete testosterone which is vital for spermatogenesis[8]. Adedara et al., reported a decrease in level of FSH and LH in pituitary in adult male wistar rats[9]. Pandey et al. reported a dose dependent decrease in the body to organ weight ratios of testes, seminal vesicles, prostate gland and seminal vesicles[11]. The histology of testes, seminal vesicles and epididymis also changes. The sperm count and motility also decrease. The seminiferous tubules shrink and the number of basal spermatogonia decreases[12]. Pandey and Srivastava observed an increase in sperm abnormalities at higher doses[13].

In female rats, it was observed that with a dose dependent increase; the ovulation was inhibited[10]. During pregnancy, there was a reduction in the number of pups and number of implantation frequency. The fetus if born is either abnormal or still born[7].

Impact on Humans

Nickel accumulates inside the cell resulting in an increase in oxidative stress. This increase in oxidative stress increased the level of lipid peroxidation in both ovaries and testes, damaging the lipid bilayer membrane and other lipid containing molecules[7]. However, in ovaries there is a decrease in level of total ascorbic acid, protein, glutathione and that of superoxide dismutase and catalase. Whereas, in testes, the concentration of protein and lactate dehydrogenase decreases and the level of testicular glycogen and cholesterol increases. Nickel also alters the enzyme activity be decreasing its activity. There is a decrease in the activity of two enzymes involved in steroidogenesis which are 3 β hydroxysteroid dehydrogenase which is involved in conversion of Pregnenolone to Progesterone, Dehydroepiandrosterone to Androstenedione and Androstenediol into Testosterone and 17 β hydroxysteriod dehydrogenase which is involved in conversion of Dehydroepiandrosterone into Androstenediol, Androstenedione into Testosterone and Estrone into Estradiol[14, 15].

2. Mercury – It occurs in elemental, organic and inorganic form. The exposure of human usually takes place either via food chain or through button cells, cosmetic creams, broken thermometers, fluorescent light bulb or dental amalgams[5].

Impact on Rats and other animals

Merlo et al observed that when female wistar rats were treated with $MgCl_2$ there was an irregularity in estrouse cycle and the time period of each phase of cycle was abnormal. There was a reduction in number of ovarian antral follicles and an increase in the lipid deposition and atretic ovarian follicle number[5]. The histopathology of ovaries alters when exposed to mercury vapor. It was observed that there was reduction of the total number of primordial germ cell, primary germ cell and graafian follicles. The mean volume of corpus luteum, graafian follicles and ovaries was found to be reducing. The fetal losses during pre-implantation and early post implantation period were found to be increased in female mice when treated with 7.5 mg methyl mercury chloride[19].

A study done on male hamsters, guinea pigs and mice showed that mercury causes impairment of spermatogenesis, decreases the motility of spermatozoa. Also, degeneration of spermatogenic cells and testicular degeneration along with cellular damage of leydig cells and seminiferous tubules was observed[20, 21].

Impact on Humans

When mercury enters the body, it starts disrupting the protein structure especially tertiary and quaternary by binding to free functional groups present in proteins, catalyzing the amino acid side chain or by displacing the essential metal ions in metalloproteins thereby impairing the cell structure. It accumulates in the ovaries and causes change in the reproductive behavior, leads to ovarian failure and infertility. A review on the effect of mercury on humans reported that high level of mercury can be associated to fertility and subfertility. High levels of mercury were found in hair, blood and urine samples among infertile subjects who had idiopathic infertility. It also increases the incidence of menstrual and hormonal disorders along with adverse reproductive consequences[16, 17].

It is shown to have an inhibitory effect on the release of follicle stimulating hormone and luteinizing hormone from anterior pituitary which can alter the levels of estrogen and progesterone leading to irregular or painful menstruation, premature menopause and ovarian dysfunction[18].

3. Cadmium – Its major use is in nickel – cadmium batteries, alloy bearing, electroplating and is also found ores[5].

Impact on Mice

In female mice, it accumulates in the ovaries and decreases the relative volume of growing follicles along with distorted Graafian follicle and increases the atretic follicle and stroma. In the oviduct, cadmium changes the structure and function by disintegrating capillary wall and inflammation of tissue[23, 24, 25].

When male mice were exposed to cadmium, it induced alteration in sertoli cells, seminiferous tubules; blood test is barrier and spermatozoa loss. This was observed in humans as well. In leydig cells, the development and function is altered along with induction of tumors. The blood test is barrier is damaged due to disruption in vascular system. The epithelium of seminiferous tubules starts degenerating and germ cells mortality takes place when mice are exposed to cadmium orally[26]. The study which focused on the mechanism of cadmium

induced toxicity in male micerevealed dose dependent severity of testes injury. At low doses, the thickness of seminiferous tubule walls decreased, while a medium dose caused the thinning of germinal epithelium, decreased spermatogenesis and bleeding in testicular stroma and a high dose, caused excessive thinning of germinal epithelium, testicular stroma abnormalities and low level of spermatogenesis in seminiferous tubules[26].

An increase in malondialdehyde while a decrease in superoxide dismutase, catalase, glutathione, lactate dehydrogenase and alkaline phosphatase is observed when rats received subcutaneous dose of 3 mg/kg body weight once a week for four weeks[22].

Impact on Humans

A study on women who were occupationally exposed to cadmium showed that the follicle stimulating hormone and luteinizing hormone decreases and an increase in level of malondialdehyde and hydrogen peroxide is observed with decrease in catalase, superoxide dismutase and glutathione peroxidase[27].

4. **Lead –** It is used in paints, lead acid batteries, smelters, printing presses, and coloring agents and in the form of alloy as shielding material[5].

Impact on Mice

When mice were exposed to lead, the accumulation was found in ovaries with dysfunction folliculogenesis, where primordial follicles were decreased but atretic antral follicle was increased[29].

Histomorphology of ovaries was found to be altered. Atresia in all levels of folliculogenesis, edema and necrosis in ovarian follicles. In uterus, inflammatory alteration characterized by narrow uterine lumen, endometrium atrophy, and vacuolar degeneration in endometrial epithelium and damaged and decreased number of endometrial gland[32, 33, 34].

In males, lead reduces decreases the spermatozoa quality by impairing spermatogenesis by affecting the hypothalamic – pituitary – testicular axis thereby suppressing testosterone production. The exposure affects the spermatozoa viability, motility, chemotaxis of sperm – oocyte fusion and DNA fragmentation by increasing the generation of reactive oxygen species[35].

Histomorphology of testes in mice reported disorganization of seminiferous tubules, shrunken and distorted tubules with complete absenteeism of spermatogenesis process, edema, inflamed tunica albuginea and hydrocele[36].

In a dose dependent study on male rats, it was observed that the blood capillaries in the interstitium were dilated, the basal membrane was undulated and the seminiferous tubules had empty spaces and the apoptosis of spermatogenetic cells was increased[37].

A study in male rats found that there was an increase of ROS levels, lysosomal enzyme activity and Malondialdhyde levels (MDA) whereas a decrease in serum LH and testosterone level, testicular 17 β hydroxysteriod dehydrogenase activity, androgen receptor expression, spermatozoa count, viability and motility and catalase and SOD levels[38,39].

Impact on Humans

A study showed that lead exposure leads to hormonal imbalance thereby causing reproductive impairment and accumulation in endocrine gland. The hypothalamic pituitary axis was affected which caused blunt response of thyroid stimulating hormone, growth hormone and luteinizing hormone and follicle stimulating hormone to thyrotropin releasing hormone, growth hormone releasing hormone and gonadotropin releasing hormone[28]. A study on female workers working in lead storage batteries found increase incidence of polymenorrhea, hypermenorrhea, prolonged and abnormal menstruation and spontaneous abortion[13]. With increase in blood lead levels, an increase in serum FSH level was observed in postmenopausal women, premenopausal women and in those where ovaries were removed, suggesting that lead exposure affects ovarian FSH and LH concentration[30, 31].

Current Research Gaps

There are a number of studies which show the effect of metal toxicity on reproductive organs but in all of these studies the major target organs are ovaries and testes, there are very few studies done in order to see the effect of toxicity on accessory organs. The accumulation of these metals in human is through bioaccumulation, so the dose at which these metals would start getting toxic would vary in humans as compared to the one shown in model organism. The dose for human is still unknown yet.

Future perspectives

The studies done this far is majorly on the effect of toxicity on the reproductive outcomes. With increase in use of nanoparticle technology, the toxicity is also increasing and there are limited studies which shows protective role of some vitamins or constituents against the toxicity[40]. Research can be done on drug discovery with natural constituents which can be used against these toxicities to lessen its severity. Studies can also be conducted to assess the genotoxic effect of heavy metals in mammals. Moreover, strategies for the prevention of toxicity should be investigated such as giving protective gears to those who are occupationally exposed to these metals, industrial water should not be discarded into the water bodies in order to avoid accumulation into aquatic organisms and use of such metal salts in agriculture should be avoided.

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Circadian Rhythm Disruption and its Role in Colorectal Cancer

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Abstract

Circadian rhythms are sleep-wake cycles that show a 24-h oscillating pattern in almost all species' metabolic, physiological and behavioral functions. There is a rhythmic synchronization in transcriptional expression of various clock-controlled genes organized in a network of the biochemical cycle in the suprachiasmatic nucleus and peripheral tissue making cell-autonomous clock pacemakers. Cellular functions like cell division and proliferation are also regulated by Clock-genes. Disturbance in this synchronicity can cause several pathologic conditions, including various cancer progression. According to International Agency for Research on Cancer (IARC), shift work that interferes with the circadian cycle can be carcinogenic to humans. Period genes (Per2, Per1) are essential circadian clock genes, which regulate β-catenin and cell proliferation in colorectal cancer cells. The mechanisms liable for the connection between the circadian clock and cancer are not well defined. Shift work and nocturnal light exposure are related to circadian clock disruption and increased cancer risk. This review discusses how disrupted circadian rhythm or "Biological Clock" could be involved in colorectal cancer development.

Keywords

Circadian rhythm, Colorectal cancer, Suprachiasmatic nucleus, *period genes.*

Introduction

There has been a recent surge of research evaluating sleep disturbances and their correlation with the health of an individual. Acute sleep impairment raises the risk of hormonal imbalance, like Elevated levels of evening cortisol, Reduced levels of glucose tolerance and Growth hormone, high estrogen, and low testosterone. It can also cause a significant increase in markers of systemic inflammation, increased blood pressure, and cognitive dysfunction. [1, 2]Emerging research outcomes suggest that circadian rhythm disruption may also increase the risk of several types of cancer. In particular, night shift workers are at higher risk of developing cancer in the breast, endometrium, prostate, and colorectum. [1]Whereas many research studies suggest the direct association of circadian rhythm and tumor progression. Quality of sleep and its relation to cancer development duration has been under-researched. Most studies reported till now are restricted to breast cancer.

Colorectal cancer (CRC) is one of the most widespread cancers with the highest mortality rates in western countries. [3] CRC is the most common cancer with the highest mortality in European countries. Black community of America and Africa are most likely suffered from Colorectal cancer. While North America and Asian countries had similar CRC incidents. Africa had the lowest incidence in the world. Among Asian countries China, Korea, Japan had the highest prevalence than other countries. India had a relatively low incidence and mortality rate. [41,42,44] 70-80% cases of CRC occur sporadically. In comparison, approximately 15% of CRC cases develop due to inherited factors, such as familial adenomatous polyposis (FAP) and hereditary nonpolyposis colorectal carcinoma (HNPCC). [3-5] Sporadic human CRC can be due to various environmental and lifestyle factors, such as dietary habits, obesity, sleep disturbance, and physical inactivity. [3,5] Individuals with less than 6 hours sleep duration per day are having a 50 percent higher risk of developing colorectal cancer than those sleeping more than 7 hours. [1] Currently, Circadian Dysfunction and overall sleep quality on the risk of colorectal cancer are poorly understood. [6,7-9]

The sleep-wake cycle is regulated by two processes circadian rhythm of sleep (process S) and wakefulness (process C).[10]Process S is sleep-wake homeostasis is like a timer that creates a need for sleep. The need for sleep increases before bedtime. Process S is associated with neuronal communication inhibition in the hypothalamus, which turns off arousal mechanisms in sleep. Disorders that affect process S promotion are associated with insomnia. Process C is known as Clock-dependent alertness or circadian process that controls and

regulates the timing of sleep and its coordination with the light-dark cycle (Day-Night), which promotes wakefulness is responsible for promoting alertness, physical activity, muscle tone, and hormone secretion over 24 hours. Process S builds pressure to fall asleep. While process C regulates daily sleep rhythm causes the body to wake up. These two processes work together to create a balanced sleep-wake cycle.[9,10]

Increased colon and breast cancer cases in developed countries are found, despite advanced screening and prevention techniques.[18] Exposure to light at night exposure suppresses melatonin production, reducing the possible nonspecific oncostatic effect of the pineal gland, thus increasing the risk of colorectal cancer. Melatonin is a potent anticarcinogenic molecule, and the relation between light exposure at night and CRC risk through the melatonin pathway could give one plausible explanation .[19,24]

Environment and Molecular regulation of circadian rhythm

Most physiological and behavioral functions in humans are regulated across days and nights in a synchronized pattern. They automatically exhibit the regular sleep and wake-up cycle. In visual perception light intensity is detected by photoreceptors in retina and process the vision at any time of the day or night. The mammalian, there is a distinct circadian photoreception pathway that is quite different from visual perception that is light-dependent non-visual (NV) responses such as suppression of melatonin, increase in body temperature due to excessive heat and heart rate, and cortical brain activity. Light through non visual retinal projections will stimulate control of alertness, sleep and mood. Melanopsin-expressing retinal ganglion cells are responsible for recognition of light, transmitted to the Suprachiasmatic Nuclei SCN clock via the retinohypothalamic tract. [11-14] Melatonin release and its circulating level are suppressed when light information is conveyed to SCN. For the adaptation to earth's rotation, there is a complete 24 hours' oscillation pattern for regulating metabolic, physiological, and behavioral functions. [14 16 18-13]Apart from SCN, there are some extra-SCN brain regions in certain organ tissues. Peripheral oscillators or slave oscillators are circadian oscillators located outside of SCN (master oscillator in a mammal) in peripheral organs (Lungs, liver, GI tract, kidneys, and other organs). [12,13] Peripheral oscillators contain certain functional circadian oscillators that respond to various non-photic stimuli like temperature, environmental or chemical cues.[12-15]

The molecular generation of circadian rhythms regulates biochemical pathways in the suprachiasmatic nucleus and peripheral tissues. [11-14] (Figure 1: Mammalian molecular circadian clock machinery Light-dark phase)

i. When the retina perceives light, positive and negative auto regulatory feedback loops in SCN Clock.
ii. The SCN oscillator contains interlocking transcription/translational feedback loops which regulate and control circadian timing.
iii. The master genes CLOCK: BMAL1 or CLOCK: NPAS2 heterodimer are the positive elements called "core loop" and transcribe Per, Cry, and Dec through E-box–mediated transcription.[12-14]
iv. The accumulation of PER-CRY heterodimer in cytoplasm acts as a negative element as they phosphorylate and translocate into the nucleus for the inactivation of the BMAL1: CLOCK BMAL1:NPAS2 E-box–mediated transcription and transcription of their genes.[12,13]
v. Degradation of PER: CRY adequately allows a new transcription cycle. While DECs bind to the E-box element and directly inhibit their transcription. (Figure 1) [12,13,15,43]
vi. Core circadian gene's (CLOCK: BMAL1 or CLOCK: NPAS2) primary feedback loop cannot maintain 24-hour rhythms, hence some other additional clock genes (REV-Erba, Period; PER, Cryptochrome; CRY, and Circadian Controlled Genes; CCGs) are associated that form a secondary auto-regulatory feedback loop. [14,15]
vii. The competitive activity of REV -Erba on the retinoic acid-related orphan receptor response element (RORE) inhibits transcription of BMAL-1, which is a stabilizing/auxiliary loop. (Figure 1) [13,14,43]
viii. Cyclic accumulations of clock-controlled gene (CCG) mRNA species by regulation of clock components via Core and stabilizing/auxiliary loops generates various physiological outputs in a cell (cell cycle and arrest, immune function, hormonal regulations, maintaining body temperature, cellular metabolism, DNA replication/repair and response action to anti-cancer drugs). [12,15,16]

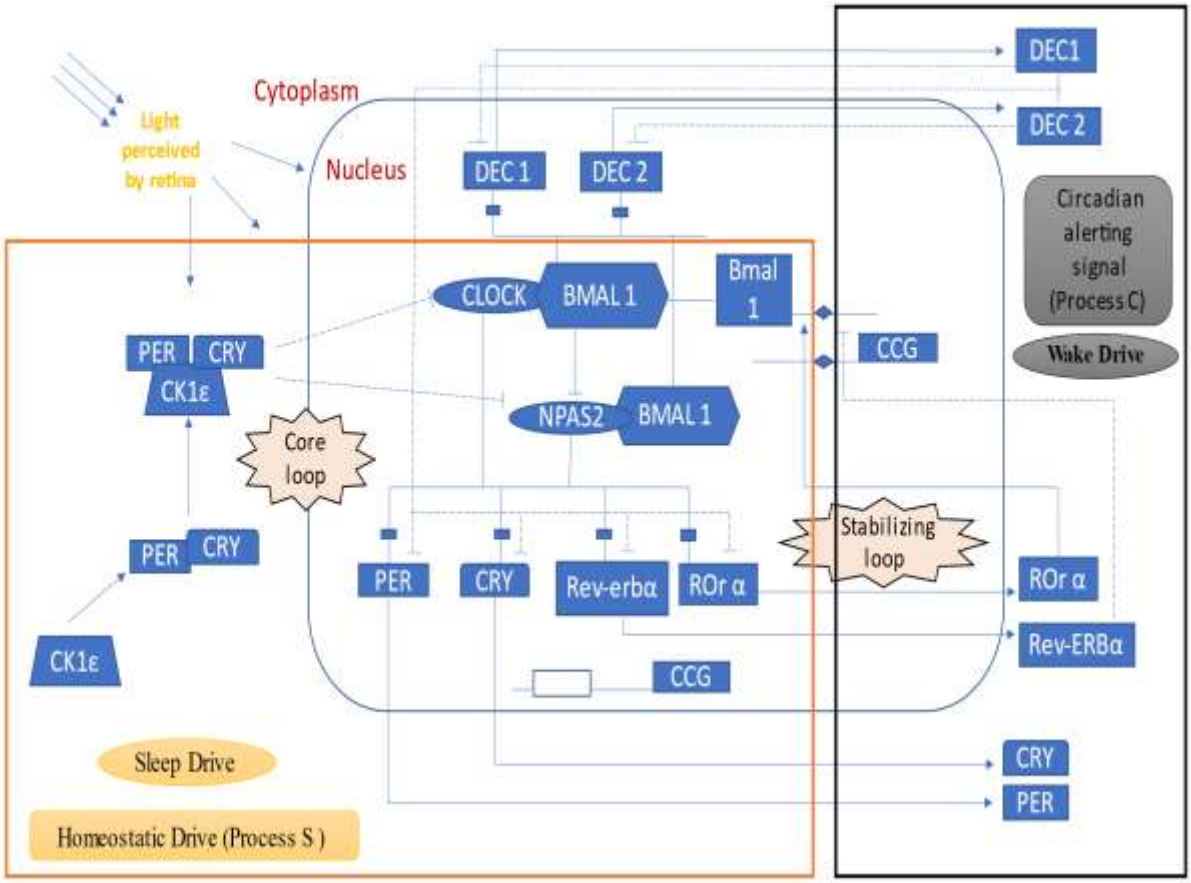

Figure 1: Mammalian molecular circadian clock machinery (Light-dark phase)

Disruption of Circadian rhythm

Disruption of the circadian clock or any alterations in clock genes results in abnormalities in various function cellular functions like proliferation, apoptosis, DNA damage response, and metabolism, which can lead to cancer initiation and progression. [13] Disturbed circadian rhythms are directly or indirectly linked for causing or promoting various forms of cancer in humans. According to the past few research studies sleep dysfunction is associated with the pathogenesis of cancer and its progression. [12,13,14] This Endogenous timekeeping circadian clock regulates the system to controls multiple peripheral clocks present in peripheral tissues of the body. Dysfunction of the circadian clock gene accelerates tumor progression, and potentially restoring circadian rhythms should improve prognosis. [6,13,14,16]

Clock genes and colorectal cancer

Circadian oscillation of Per1 and Per2 is found in the oral mucosa and colon crypt cells independent of the SCN. [17,25,26] PERIOD proteins play a significant role in the circadian clock and tumor suppression. Per1 and Per2 mutations have been detected in the sequencing of colorectal tumors. PERIOD proteins regulate cell cycle progression via circadian gated expression of cell cycle proteins (WEE1, cyclins, p21, p53), controls cell cycle regulators (b-catenin, vascular endothelial growth factor [VEGF], cyclin D, c-Myc), regulate DNA damage response, and also modulate other clock genes (*Per1*, *Bmal1*). [12,15,25] Per2 mutation and ApcMin/+, the mutation act together to potentiate intestinal polyp formation. [12] In colorectal cancer cell lines increase in expression of PER1 leads to DNA damage-induced apoptosis, whereas its inhibition causes blunted apoptosis by disrupting circadian control of b-catenin-dependent pathways and alterations in the DNA damage response. CTNNB1 is a controlled clock gene functions as an oncogene, influencing cell proliferation in colon cancer cells. PER1 and PER2 encoded by CTNNB1 participate in ATM-Chk1/Chk2 DNA damage response pathways and modulating ß-catenin, whose promoter shows BMAL1. [12-14] Melatonin hormone is secreted by the pineal gland regulated by a rhythm-generating system located in the SCN, which is in turn regulated by photo stimuli. Melatonin acts as a darkness signal, providing feedback to the SCN oscillators. Melatonin has both induce sleep and an ability to entrain the sleep-wake rhythm.[6,20]Melatonin has been proven to show anti-cancer properties in animal models to reduce DNA adducts and promote DNA repair by reducing the overall DNA damage and inhibiting the cell cycle to decrease cell proliferation. [20-23]Exogenous melatonin could restrict tumor growth and restore circadian rhythmicity. [23,31,32]Alteration of rhythmic motor activity and adrenocortical secretion is associated with poor survival of patients with metastatic colorectal.

In an experiment with mice, SCN was destroyed before transplanting tumor; transplanted tumors grew twice to thrice faster than in operated mice. 12-hours of light and dark phases to maintain SCN-independent photoperiodic synchronization. [2936,28]When rhythms of clock genes were suppressed in jet-lagged mice, down-regulation of p53 and overexpression of c-myc occurred, and both contribute to tumor progression. [26-28]

Disturbance in the peripheral intestinal circadian clock can lead to intestinal epithelial neoplastic transformation of human CRC.[33] Circadian disruption is classified as "probably

carcinogenic," according to humans by the International Agency Research on Cancer (IARC). Sleep disturbance affects the secretion of melatonin and is associated with a decrease in removing free radicals and protecting against oxidative DNA damage. [33-35]

Inadequate sleep may reduce the release of immune-stimulating hormones, such as growth hormone, prolactin, and dopamine, and affects functions of pro-inflammatory cytokine genes, including interleukin-6 (IL6) and tumor necrosis factor-α (*TNFA*). [36,37] These alterations can lead to cellular and genomic markers of inflammation and contribute to CRC development. [38,39,43] These above-mentioned pathophysiological factors may explain the association between circadian rhythms disruption and CRC.

Significant gaps in the research

Considering the evidence mentioned above from various studies, light reduces circulating melatonin levels, increasing colorectal cancer risk, especially in night-shift workers.[19] EM waves have also been considered another pertinent modern environmental influence that suppresses melatonin levels as low exposure to low-frequency EM fields can increase colon cancer risk.[29] Apart from disrupting circadian rhythm, EM waves can directly interact with colon tumor cells and affect their proliferation. [30,40]Disruption of circadian rhythms is majorly due to the Modern lifestyle. Any genetic variations and their interaction with certain environment cues (even Disruption of circadian due to exposure to light during the night) can lead to cancer development. Primarily colorectal cancer could be explained by any of these mechanisms. Complete understanding of molecular mechanisms that form an interrelation between disruption of Clock controlled genes and Colorectal cancer development is still understudied. A comprehensive evaluation of how a disrupted circadian peripheral clock contributes to tumor formation in intestines is essential for developing future circadian clock–based strategies to prevent colorectal cancer and development. [22,35,40]

Underlying Molecular mechanisms that associate sleep duration with colorectal cancer initiation are largely under-researched. Less than 6 hours of sleep can disrupt circadian rhythm and suppress the production of melatonin which leads to the development of colorectal adenomas are evaluated; till now, there is no study proving how sleep quality affects human health and cancer progression.

Future Directions

Circadian rhythms disruption has a substantial impact on gastrointestinal diseases and colorectal cancer development. Conversely, many gastrointestinal disease processes influence the sleep-wake cycle and sleep quality. It is considering recent research that has shown a vital significance of sleep and its impact on colorectal cancer development and progression. Research has shown that treating a patient's underlying sleep disorder may result in improvement in their gastrointestinal symptoms. Furthermore, control of gastrointestinal disease states will result in improved sleep quality and can prevent cancer initiation. Therefore, gastroenterologists need to take a detailed sleep history to identify any underlying gastrointestinal diseases and colorectal cancer early diagnosis to better care for patients.

Glossary

- **Systemic inflammation**: inflammation in the whole body
- **familial adenomatous polyposis (FAP):** genetic cancer predisposition of a precancerous polyp
- **hereditary nonpolyposis colorectal carcinoma (HNPCC):** a dominant genetic condition that causes the highest risk of colon cancer.
- **Hypothalamus**: region of the brain at the base of pituitary gland responsible for regulating hormones and body temperature.
- **Suprachiasmatic nucleus SCN**: region of the brain in hypothalamus situated above optic chiasma
- **Retinohypothalamic tract**: photic neural input passage from eyes to hypothalamus
- **Apoptosis:** Programmed cell death pathway. This process to remove damaged cell in normal physiology.
- **Vascular endothelial growth factor (VEGF):** a protein that promotes the formation of new blood vessels
- **Cyclins**: protein family that control cell progression associated in cell cycle
- **EM:** Electromagnetic Radiation

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Primordial Origin of Cancer

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Abstract

Oncological disorders are the second leading cause of death worldwide and now it has become a major threat in public health worldwide. We must understand behavior of cancer from evolutionary aspects to prevent, manage and treat this disease in a right way. This review, hypothesize the evolution and origin of cancer from unicellular organisms from different mechanisms, and microbiome interact with cancer cells in tumor microenvironment to protect and support each other and this plays important role in cancer formation and development. Also, the importance of healthy lifestyle and diet can prevent from causing cancer in later life is also discussed.

Keywords

Cancer, microbiome, unicellular organisms, tumor microenvironment, evolution, lifestyle and diet.

Introduction

Cancer is a disease as old as humankind. It has most likely been nearby since the multicellular organisms came into existence.[1]Besides, some Dinosaurs of the Jurassic period equally suffered from cancer.[3] However, the fundamental queries such as, what exactly is cancer and why does it exist, are currently unclear and unanswered. Despite of significant advances in our practical understanding of the disease, the origin of cancer remains a mystery.

Cancer is a multifactorial disease; nowadays, bad dietary habits, sedentary lifestyle, lack of sleep, environmental pollution, and temperature changes have undoubtedly become the crucial reasons for causing microbiota dysbiosis. Even a healthy diet plays a vital role here, nowadays, people are moving away from the traditional dietary pattern, which influences the risk of cancer. Recent studies showed that intake of a proper traditional diet, such as seasonal fruits, raw vegetables, legumes, probiotics, and good carbs has increased the beneficial and protective effects.[6] Therefore, avoiding cigarettes smoking, limiting alcohol consumption, maintaining normal BMI, regular exercise and proper sleep are effective steps for not only preventing cancer but also for other lifestyle diseases and disorders.

Cancer typically undergoes various complex biological processes and consists of a complex biological network, and it is hypothesizing through the process of positive and negative natural selection, which has been described by Charles Robert Darwin.[4] Natural selection theory suggest a mechanism of evolution. Organisms that are adapted to their environment are more likely to survive. This causes species to change and diverge over time. Positive and negative natural selection are types of natural selections, positive selection means variation or change that causes positive impact on the population, whereas negative selection means the variation or change cause deleterious impact on the population. During the evolution of multicellular life, it has presented major alterations in genetic and cellular phenotypes also observed in cancer,[1] but why such specific alterations naturally take place in cancer is still unknown. To perceive the accurate behavior of cancer, we must understand it through evolutionary theory, and this would provide perspective to develop a novel system and strategy to fight against cancer. Interestingly, there are various theories suggesting cancer formation is associated with the microbes which reside in the human body. However, these microbes play a vital role in the metabolism of nutrients, but changes in the microenvironment of the body engage in them to evolve and influence cancer formation.[5]

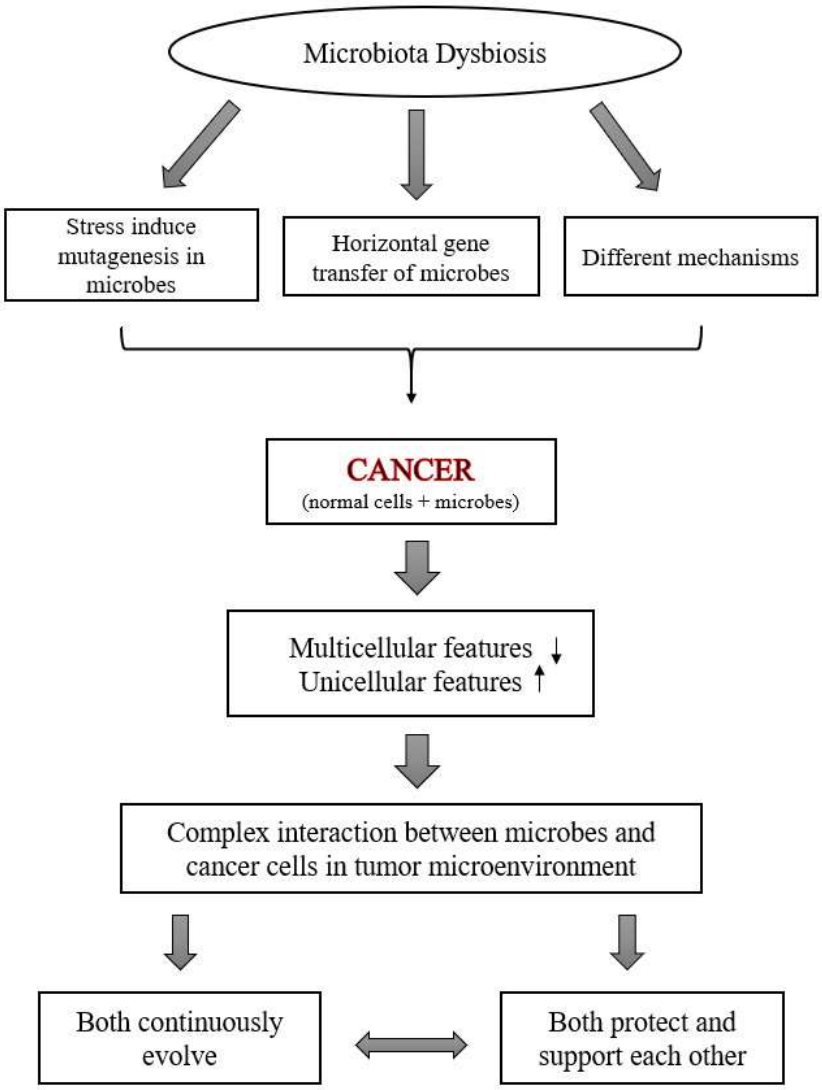

Figure 1: Environmental stress causes microbiome dysbiosis which might cause different defence mechanisms to transfer genetic material into a host's cell. Due to this in cancer, multicellular network downregulates and ancestral unicellular network upregulates. Also, Microbes resides inside the tumor microenvironment and might be forming a complex network to interact with cancer cells.

Lifestyle and cancer

The ecosystem of microbes is rapidly influenced by acute and chronic dietary habits and lifestyle, thereby to maintain a habitual environment for microbes, the importance of a balanced diet has widely come into highlight over the recent decade.[40-42] Certain lifestyle habits like poor diet, stress, and lack of exercise directly affect the gut microbiota, some other factors like age, xenobiotics, drugs, and also environmental changes cause imbalances in gut microbiota equilibrium. Such factors impair the gut microbiota composition and functions, which is known as gut microbiota dysbiosis.[43] There are various recent shreds of evidence supporting the relationship between gut microbiota dysbiosis and cancer development.[44] Some studies also demonstrate the effect of dysbiosis linked with various diseases and disorders, such as inflammatory bowel disease (IBD), ulcerative colitis (UC), obesity, diabetes, cardiovascular disorders, and metabolic disorders.[45-49] Lifestyle and diet are within one's power to improve. There are various factors such as lifestyle, environmental changes, dietary habits, etc. play a significant role in developing cancer. Even a healthy diet plays a vital role, nevertheless, people are moving away from the traditional dietary pattern i.e., Indian dietary pattern, and moving towards consumption of high-fat diets or Western-style diets, which are associated with cancer development and progression.[50] However, the vegetarian dietary pattern and consumption of more plant-based foods, such as fruits, grains, and vegetables have been associated with cancer prevention and overall improve one's health.[51]Therefore, prevention is better than cure.

Microbes, Cancer cells, and Microenvironment

Normal human somatic cells and microbes present inside the body as commensal microbe maintain a healthy relationship with each other, body provide an environment and resources for microbes to live in, they metabolize the nutrients and protect the body from invading pathogens.[33] During cancer formation, this secure environment for microbes no longer stays safe hence results in dysbiosis, the cooperation between normal cells and microbes disturbs thereby cancer cells and microbes to cooperate and enhance each other. In carcinogenesis, bacteria carry out a critical role; they act as carcinogenic and tumor stimulating agents. They possess the capacity to secrete toxins that can convert the signals responsible to regulate a cell.[21] Many bacteria are associated with causing numerous types of cancers, such as *Salmonella typhi* (Hepatobiliary carcinoma), *Helicobacter pylori* (gastric cancer), *Chlamydia*

pneumoniae (lung cancer), *Streptococcus bovis* (colorectal neoplasia and lung cancer), *Escherichia coli* (colon cancer), *Chlamydia trachomotis* (cervical cancer), etc.[22] These bacteria are present not only in the human GI tract but also present in breasts,[23] lungs,[24] ovaries,[25] and prostate.[26]these bacteria play very important role in our body, they help in metabolism of certain compounds and molecules which are usually cannot be metabolize by our body but essential for our body, for instance, dietary fibers. Interestingly, these cancers are the most recurrent cancers among the human population. In stressful conditions, however, these bacteria are currently believed to modify and alter human DNA thereby disturbs the cell cycle, cell death, and increase cell proliferation.[5]Tumor cells continuously evolve inside the ecosystem of the human body, simultaneously they form a microenvironment around the tumor, hence it is called tumor microenvironment. In this microenvironment, there are various growth factors are present to promote cancer progression.[27] Microbes may reside in or near the tumor microenvironment and alter the environment for their convenience by producing factors or bacterial biofilm which influence cancer cell progression.[5] To support this statement, a recent study has discovered the presence of bacterial LPS (Lipopolysaccharide), DNA (Deoxyribonucleic acid), and 16S rRNA (ribosomal Ribose nucleic acid) in cancer and immune cells as well. To a great extent, they argued that different tumor cell types consisted of particular microbial compositions in breast, lung, melanoma, pancreas, ovary, bone, and GSM cancers. After DNA sequencing of bacterial DNA, they found 137 intratumoral bacterial species that are typically associated with various cancers.[28] Therefore, this not only shows a direct relationship between microbes of the microbiome and the formation or development of cancers but also shows the evidence of horizontal gene transfer. Horizontal gene transfer is the movement or transfer of genetic material, like DNA/RNA, between unicellular and multicellular organisms.

The presence of bacterial molecules in tumor cells and behavior of cancer similar to microbes uncoupled novel insights towards horizontal gene transfer (HGT) which shows crosstalk between microbes and human somatic cells during cancer formation. Recent studies have indicated new mediators of HGT which includes apoptotic bodies[29] – apoptotic bodies are a vesicles that contains parts of dying cell – and circulating cell-free DNA.[30,31] These mediators are actively involved in cancer progression and metastasis, as well as drug resistance.[32] Another study suggests, according to the bacterial origin of cancer cells (BOCC) theory, cancer cells arises from the bacteria when the environment in the body is compromised, these bacteria enter

into normal body cells and make a hybrid DNA, further it leads to formation of cancer cells.[20] This theory not only supports HGT but also supports stress induce mutagenesis, during stressful condition, microbes induce drastic changes on genetic level to survive in such condition. It is a survival or defence mechanism. These theories and evidences support during stressful condition and environment, how bacteria are not only involved in progression of cancer but also involved in the process of carcinogenesis.

Microbes promote and initiate cancer through different mechanisms

There are various mechanisms through which cancer cells and microbes influence each other for their survival.[5]Microbes such as E. coli produces some genotoxins like colibactin which induces breakdown of host DNA.[34] Microbes also produce reactive oxygen species that damage the host DNA.[35] Therefore, this results in the formation of cancer. Cancer cells and microbes together not only provide growth factors to each other but also protect one another from the body's immune system. For instance, cells in the tumor microenvironment are no longer capable to divide yet they produce growth factors and bacteria like E. coli is capable of producing toxins such as colibactin which may mediate this signaling pathway and also induce to release of growth factors that promote tumor progression.[36] Typically, microbes in the gut interact with the human immune system but in inflammation, the condition causes bacterial infections which alter adaptive and innate immune signaling as a result of developing cancer.[37] Many microbes use host cells to develop their ecological niches, particularly Fusobacteria invades into a host cell and expand its niche by promoting cell proliferation.[38,39] These reactions of bacteria could be due to the stressful environment for them inside the body, therefore, this might be the defence mechanism of microbes against the environmental imbalances in the host body.

Multicellularity evolution and origin of cancer

The hallmarks for cancers are core principles of tumorigenesis,[15] they provide a unified framework to study the molecular drivers of cancer. Multicellular organisms are evolved from unicellular organisms millions of years ago. Unicellular organisms have basic and simple biological network while multicellular organism evolved and went through various types of variations to form a complex biological network. Although, multicellular organisms still possess unicellular network but it is not in function. So, in cancerous condition, cancer cells

activate the unicellular network and deactivate multicellular network due to genetic alterations.[1] There are many similarities between unicellular organisms and cancer cell such as the fermentation process for cell growth,[16] under the adverse conditions, unicellular organisms employ elevation of genetic instability, which reminiscent of mutator phenotypes.[17] To survive in stressful conditions, the ancient pathways of DNA repair mechanisms such as stress-induced mutagenesis originate in unicellular organisms.[18] The genes associated with cancer are enriched in genes associated with unicellular organisms for conservation, this suggests that during carcinogenesis there is an activation of ancient parts of the unicellular network. This is described as the atavism hypothesis of cancer.[19]

Results from a study suggest that they found a constant progression of tumor cell types similar to pluripotent stem-like conditions, the condition describes the ability of a cell to develop into the three primary germ cell layers of the early embryo and therefore into all the different cells of the adult body, such cell is known as pluripotent stem cells. Further, they proclaim it is a selection of unicellular condition and not the pluripotent condition. Given the fact, coinciding decrease of multicellularity features and increase in primitive features at the cellular level, therefore dependence on primitive unicellular features enhance here. This phenomenon can be activated during cancer formation because core principles of carcinogenesis are associated with the evolutionary history of the cellular and molecular network.[1,2] These studies offer a new direction towards an evolutionary perspective of the original origin of cancer from unicellular life to perceive the behavior of cancer.

Natural selection and Genetic heterogeneity of tumors

Cancer clinically manifests cellular genetic heterogeneity that expresses variation, growth, differentiation, and natural selection. Primarily, tumors were sensitive to certain therapies however, now tumors frequently acquire resistance.[7,4] Many theories suggest that resistance to therapies is due to the natural selection mechanism. Such mechanism operates in various types of cancers, for instance, breast cancer, malignant melanoma, and acute lymphoblastic leukemia.[8-10] During tumor progression, the growth of genetic diversity and heterogeneity seems to be associated with either positive selection or negative selection,[11] because interaction with the surrounding microenvironment is critically essential.[12]This results in the initiation of aggressive phenotype and metastatic behavior. Additionally, the involvement of epigenetic modifications in tumor cell genetic heterogeneity has also been seen, however, this gives

direction towards the non-Darwinian type of evolutionary approach.[13,4] Tumor cells are not solely composed of a genetically mutated cell, but also contain genetically non-mutated cells. All these various types of cells collectively form a complex ecosystem.[14] In this cancer ecosystem, the therapeutic approach initiates novel stimulus, so naturally selecting cells must survive or die. This also suggests that it encourages the chance for surviving cells to proliferate. Therefore, this evolution in tumors represents the noteworthy reason for inadequate results of cancer treatment.[4]

Significant gaps in research

Till this date, it is recognized that cancer cells evolve in the body's ecosystem and so as microbes, also how microbes influence cancer progression and metastasis is known, however, the actual motive of microbes to influence cancer formation is still unknown. Some studies have revealed the presence of bacterial molecules (LPS, DNA and RNA) residing inside the tumor microenvironment but how these molecules invaded the tumor cells and what is the role of these molecules in the tumor formation and progression is yet unexplored. If the involvement of microbes induces cancer to evolves to resist chemotherapeutic drug actions, can antibiotics use in combinations with chemotherapeutic drugs for better treatment? Recent findings have also shown that bacterial molecules are not only present in tumor cells but also present in immune cells, however, why microbes choose to invade specific immune cells and what exact role and mechanism of these molecules in immune cells have with cancer progression is undefined. Cancer is continuously evolving and causing thousands of mutations, but where exactly this evolution will lead cancer to in the future, this aspect is still unanswered. Nevertheless, due to such behavior of cancer yet one critical question is still undefined that are cancer cells new unicellular eukaryotes?

Future directions

In the future, work should focus on understanding the origin and behavior of cancer, and the interaction between microbes, cancer cells, and normal cells. This will present new insights into the possible outcomes in evolutionary pathways of cancer, which will help to understand how cancer can be managed, treated, and prevented in the future.

Conclusion

Natural selection in cancer shows the heterogenicity in the genome of cancer, which is equally responsible for dependence on ancient parts of genes rather than a multicellular network of genes. Cancer can be derived from the unicellular organisms which reside in the human body; microbiome. The human microbiome plays a vital role in cancer progression and development. Microbes reside in or near tumor microenvironment so that they can interact with cancer cells and influence each other to evolve and sustain in the body's ecosystem via various mechanisms. However, a balanced vegetarian diet and a healthy lifestyle possess preventive measures towards cancer initiation.

Glossary

Adaptive immune system – Immunity that develops after exposure to an antigen.
Biofilm – A complex structure of different bacterial colonies that adhere to the surface.
BMI – Body mass index is a measurement of body fat based on height and weight.
Carcinogenesis – A process of cancer formation.
Circulating cell-free DNA – Degraded DNA fragments released to the blood stream.
Commensal microbe – Microbes that supply essential nutrients to host and fight against opportunistic pathogens for host.
Deoxyribonucleic acid – Genetic material in organism.
Epigenetic – The study of how behavior and environment can cause changes that affects the way genes work.
Genotoxins – Chemicals or agents that can cause damage to DNA.
Heterogenicity – Two or more genetic elements that does not have common ancestry.
Innate immune system – Immunity that is naturally present in the body.
Lipopolysaccharide – The outer membrane of gram-negative bacteria.
Metabolism – The biochemical process by which body coverts food into energy to maintain functioning of organs Multicellular – More than one cell.
Metastasis – A process when tumor cells move from main tumor and enter in the bloodstream.
Microbiota – The assemblage of all the different microorganisms that are present in a defined environment.

Microenvironment – Immediate small-scale environment of a group of cells, as a distinct part of a large environment.

Mutagenesis – A process in which genetic information is changed due to mutation.

Phenotype – An observable trait of an individual.

Proliferation – Rapid division of a cell.

Ribonucleic acid – Similar molecule to DNA, act as a genetic material in some unicellular organism.

Signaling pathway – Chemical reactions in which molecules in a cell communicate and control a cellular function.

Somatic cells – Cells of body except sperm and egg cells.

Tumorigenesis – Gradual loss of normal properties of cell and gain malignant properties.

Unicellular – One cell.

Xenobiotics – Chemical substances that are not naturally produce by an organism but found within an organism.

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Anti-Cancer Effect of Solanum Nigrum on Colorectal Cancer

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Abstract

Colorectal cancer is the third most occurring cancer in the world. The major causes of colorectal cancer are obesity, poor nutritional habits and eating patterns, smoking, and the progressive aging of the population. The Solanum nigrum is a shrub-like plant traditionally used for curing many diseases, using the various parts of Solanum nigrum. Solanum nigrum is therapeutically used for gouty joints, anti-tuberculosis, cough, inflammation, skin diseases, digestive issues, asthma, rheumatic arthritis, nausea, cardiotonic, and various nerve disorder, and for depressing and calming the Central nervous system (CNS) and spinal cord. Solanum nigrum also shows the anti-cancer effect on liver cancer, lung cancer, prostate cancer, and breast cancer. The glycoproteins constituents and glycoalkaloids like alpha-solanine of Solanum nigrum have an anti-cancer effect on colorectal cancer. Glycoproteins and alpha-solanine can target and cause apoptosis, control the Reactive oxygen species (ROS) mechanism and inhibit the expression of various mutated genes making possible therapeutic solutions for colorectal cancer. Further, research on Solanum nigrum will open many other therapeutic targets like other apoptotic genes B-cell lymphoma (BCL) and BCL-2 associated x (BAX) proteins in colorectal cancer. This review aims to understand the effect of Solanum nigrum on Colorectal cancer.

Keywords

Colorectal cancer, glycoproteins, solanine, apoptosis.

Introduction

Colorectal cancer is the most occurring cancer after lung cancer and breast cancer in cancer pathology.[1,3] In current times, colorectal cancer is the most common cancer in the gastrointestinal tract. Colorectal cancer is the most occurring type of cancer after breast cancer in women and the third most occurring type of cancer in men after lung and prostate cancer.[1] Across the world, 1.8 million cases are observed per year. A high rate of occurrence of colorectal cancer cases is seen in countries like Hungary, South Korea, Slovakia, the United States across the world.[1] The major causes of colorectal cancer are obesity, poor nutritional habits and eating patterns, smoking, and the progressive aging of the population.[3] The rise of colorectal cancer is also seen in the younger generation due to lifestyle changes. People aged above 65 and having a genetic history of colorectal cancer are at high risk of occurring of colorectal cancer.[315]

16 Poor nutrition, poor lifestyle choices, and genetics may cause mutation in various genes in the gastric canal cells. The major genes involved in colorectal cancer are Adenomatous polyposis coli (APC), Deleted in colorectal carcinoma (DCC), B-raf protein (BRAF), Phosphatidylinositol-4,5-bisphoshate3-kinase, catalytic subunit alpha (PIK3CA), Protein B kinase (AKT), Tumor protein-53 (TP53), K-ras proteins (K-RAS), and Catenin B protein (CTNNB).[3] These genes and proteins play important role in the cell cycle, cell progression, and cell proliferation in both normal cells and cancer cells, which makes potential therapeutic targets for cancer. In colorectal cancer treatment, K-RAS mutation is considered a bad prognosis but it is also considered to be a biomarker that predicts the response to the treatment.[3]

The current curative treatments for colorectal cancer across the world are surgery, chemotherapy, and radiation therapy.[4] These current treatments are having many side effects on the patient. Although surgery is currently the most effective treatment but recurrence of cancer is observed in many patients. Similarly, for chemotherapy there are many side effects such as neutropenia, nausea, vomiting, hepatorenal toxicity, and also may show low efficacy in many patients.[4] Due to these side effects, alternative herbal medicine is being studied for a few decades. Many compounds originating from plants are evaluated for potential chemopreventive activity and also, these plant compounds are used to prevent the development of cancer.[4] According to traditional Chinese medicine, Solanum nigrum can be used

therapeutically for various types of cancer specifically, colorectal cancer.[4] This review aims to understand the effect of Solanum nigrum on Colorectal cancer.

Solanum nigrum – The plant:

The Solanum nigrum also commonly known as black nightshade belongs to the Solanaceae family of plants. Solanum nigrum is a shrub-like plant that grows in various countries around the world. It grows wildly as a weed in the field, building areas, under trees, and wasteland.[5] Some African and North American countries do semi-cultivate for many purposes.[5] Solanum nigrum is therapeutically used for various diseases condition. Solanum nigrum and many species of the same family are used as traditional medicine in various Asian countries for many diseases condition.[5] Various parts of Solanum nigrum are used for many disease conditions such as gouty joints, anti-tuberculosis, cough, inflammation, skin diseases, digestive issues, asthma, rheumatoid arthritis, nausea, cardiotonic, for various nerve disorders and for depressing and calming the Central nervous system (CNS) and spinal cord.[5,6]

Solanum nigrum has shown the anti-cancer effect on liver cancer, lung cancer, prostate cancer, and breast cancer through various cellular mechanisms like apoptosis, control Reactive oxygen species (ROS) production.[5,9,10,11,12,13]

Solanum nigrum contains secondary metabolites like alkaloids, glycoalkaloids, flavonoids, tannins, glycosides, coumarins, glycoproteins, steroids, and saponins. Solanum nigrum contain macromolecule like carbohydrate, proteins, lipids.[5] These secondary metabolites are non-essential molecules produced by plants as their defense mechanism against the various pathogens in nature. These secondary metabolites exhibit anti-oxidant, anti-inflammatory, radical scavenging, and anti-tumor properties which makes them highly therapeutic for many diseases and cancer conditions in animals and humans. [5,6,7,8]

Current research based on the effect of solanum nigrum on colorectal cancer:

The anti-cancer of Solanum nigrum and its components are studied and understood mostly in in-vitro studies and also in vivo studies. The in-vitro studies are done on carcinoma cell lines like HCT-116, HT-29, and RKO, microfluid system, and tissue culture, whereas in-vivo studies are done on rats and zebra fishes. The cell lines like HCT-116, HT-29, and RKO are human colorectal carcinoma cell lines extensively used for colorectal cancer

research. The anti-cancer effect of Solanum nigrum was studied and examined by targeting various genes, transcriptional factors, and cellular mechanisms found in colorectal cancer.

Effect of Solanum nigrum on the proliferation of colorectal cancer cells:

Cell proliferation is one of the prominent characteristics of colorectal cancer. Cell proliferation along disturbed balance in cell loss and cell gain may lead to metastasis and invasion in colorectal cancer development.[14]

To study cell proliferation, 4,5- dimethyl thiazol-2-yl (MTT) assay is performed on the cancerous cells. MTT assay is the colorimetric method used to check viability (cytotoxicity) and proliferation of cells. This assay helps to understand dead and live cells based on the treatment of solanum nigrum.

Solanum nigrum shows a strong cytotoxic and anti-proliferative effect on various colorectal cancer cells (cell lines). Alpha – solanine are glycoalkaloids, extracted from Solanum nigrum have shown an anti-proliferative effect in the dose and time-dependent manner on RKO cells.[20] The glycoproteins of Solanum nigrum have also shown anti-proliferative effect in the dose and time-dependent manner on HT-29 and HCT-116 cells through MTT assay.[17,18,19] These anti-proliferative effects of phytochemicals of Solanum nigrum show the potential anti-cancer activities on colorectal cancer.

Anti-oxidative effect of solanum nigrum on the production of reactive oxygen species in colorectal cancer cells:

Reactive oxygen species (ROS), also called free radicals are products of a cellular mechanism having a specific role in normal cells to maintain normal cellular function.[15] ROS increases in cancer cells which activate various signaling pathways during tumor progression leading high proliferation rate. So, the need for potent antioxidants in our diet and drug supplements is very necessary for Colorectal cancer.[15]

Solanum nigrum glycoproteins showed dose-dependent radical scavenging activities including 1, 1-diphenyl-2-picrylhydrazyl radicals (DPPH), superoxide radicals (O_2^-) & hydroxyl radicals (OH). The antioxidant properties of solanum nigrum glycoprotein may induce apoptosis by reducing oxidative stress in HT-29 cells. The ethanol extract of the whole plant of Solanum nigrum shows hydroxyl radical activity through increasing the concentration

of the solutes in cells. The glycoproteins also showed a significant reduction in nitric oxide radicals' production.[17]

Alpha – solanine of Solanum nigrum increased the ROS production in RKO cells which causes apoptosis (cell death) of cells. High levels of ROS production in cancer cells may cause apoptosis.[20] Different components of Solanum nigrum may show anti-cancer activities through a different mechanism. An increase or decrease of ROS can cause cell death depending on treatment, cells, and cell conditions

Apoptotic effect of solanum nigrum on colorectal cancer cells:

Apoptosis is programmed cell death, in which a highly complex cascade of cellular events that results in chromatin condensation, DNA fragmentation, cytoplasmic membrane breaking, and cell shrinkage. Caspase cascade is a group of cysteine proteases that trigger apoptosis in the cells. Caspase -3 and caspase -9 are therapeutic targets for colorectal cancer. Apoptosis is an important cancer therapeutic target, the assessment of molecular mechanisms and targeting of apoptosis-related genes lead to a new therapeutic target in curing cancer.[17]

The glycoproteins cause DNA fragmentation in the HCT-116 and HT-29 cell lines in a dose-dependent manner, studied through the Electrophoresis technique.[16,17,18,19] In many studies, the fluorescence technique is used to study DNA fragmentation quantitatively.

Glycoproteins also induce apoptosis by inhibiting the expression and signaling of Nuclear factor-kappa B(NF-kB) in the colorectal cancer cell. NF-kB is a nuclear factor, also a protein complex that controls the transcription of DNA and cell survival. The inhibition of expression and signaling of the NF-kB pathway in the cells may cause apoptosis of cells. Glycoproteins also induce apoptosis through activation of caspase -3, Prolactin receptor-associated protein (PRAP), and inhibiting the production of Nitric Oxide.[19] Solanum nigrum is one of the agents that's blocks 12-o-tetradecanoyl-phorbol-13-acetate (TPA) -induced signal responses in the cancer-tumor cells.[5]

Alpha-solanine also induces apoptosis through DNA fragmentation in a dose-dependent manner in RKO cells, studied through flow cytometry technique and fluorescence

techniques.[20] Alpha-solanine affects the caspase mechanism by targeting caspase 3, caspase 6, and caspase 9 and inducing apoptosis in RKO cells.[20]

Effect of Solanum nigrum on metastasis, invasion & tumor growth in colorectal cancer cells:

Metastasis is a biological process, which includes tumor cells diffusing from the group of primary abnormal cells (lesion), adhering to blood/lymphatic vessels, entering the blood/lymphatic circulation, adhering to the vascular endothelium, invading into target organs, and then proliferating to form metastatic condition. Metastasis and invasion are major characteristics of colorectal cancer and they may lead to liver and lung cancer. Alpha–solanine inhibits migration and invasion in HCT-116 cell lines in a dose-dependent manner.[20]

Alpha–solanine inhibits tumor growth in tumor weight and tumor volume in the nude mice. Alpha solanine targets and inhibits the Ki-67 proliferation marker in the cells of tumorous mice. Ki-67 is a nuclear protein, also used as a marker and therapeutically associated with cell proliferation and cells cycle. Alpha–solanine induces apoptosis in tumorous cells of mice through DNA fragmentation and activation of the caspase cascade.[20]

Conclusion

Solanum nigrum has been used as a folk therapeutic agent for many years. In previous studies, glycoproteins and solanine steroids isolated from Solanum nigrum had shown anti-cancer on various cancer like liver cancer, prostate cancer, breast cancer, and stomach cancer. This review demonstrates the anti-cancer effect of glycoproteins and solanine of Solanum nigrum on colorectal cancer in in-vitro and in vivo conditions.

Glycoproteins and solanine show the cytotoxic effect on HT-29 and HCT-116 cells, studied through MTT assay. MTT assay is used to study cytotoxicity/proliferation in normal cells and cancer cells.

Apoptosis is the event of cascade reaction mediated by caspase complex and it is an important mechanism for cancer therapy. In the present review, after the treatment of glycoproteins and solanine, the carcinoma colorectal cells showed apoptotic cell morphology like fragmented nuclei and these cells are densely stained with fluorescence stains due to DNA

fragmentation. The glycoproteins and solanine induce apoptosis by activation of caspase complex and inhibition of NF-kB in colorectal cells.

Reactive oxygen species (ROS) are products of cellular metabolism. The increase and decrease levels of ROS compared to the normal range of ROS in cells can cause apoptosis. Induction of ROS levels is crucial for tumor therapy. The present review shows glycoproteins have anti-oxidant properties, which lowers the level of ROS in the cells causing the apoptosis of the cells whereas solanine caused the apoptosis of cells by increasing the production of ROS in the cells.

Tumor metastasis is a multiple-step biological process, starting from tumor cells diffusing from the primary lesions, adhering to the vascular endothelium, invading into target organs, and then proliferating to form a metastatic condition. In the present reviews, alpha-solanine inhibits the metastasis, invasion, and adhesion of colorectal cancer. Alpha-solanine may have an inhibitory effect on Mycophenolate mofetil (MMF) genes. MMF- 2 and MMF -9 are metastatic genes that play a key role in the metastasis of cancer cells.

In conclusion, the present review shows glycoprotein and alpha-solanine of Solanum nigrum have an anti-cancerous effect on colorectal cancer through apoptosis, ROS mechanism, and inhibiting various genes and metastasis.

Future aspects of research of Solanum nigrum:

In the future, other phytochemicals of Solanum nigrum should be studied for anti-cancer activity on colorectal cancer and as well as other cancers. Glycoproteins and alpha-solanine can be studied on many other apoptotic genes like B-cell lymphoma (BCL) genes, angiogenesis genes like MMF -3 and MMF -9 and also should research in an in-vitro system.

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Determining the Water Solubility of Platinum, Palladium and Rhodium Sponge by Modified Flask Method to Provide Guidance on the PGM Separation

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Abstract

Platinum Group Metals (PGM) is an active component in various catalyst formulations. The water solubility of platinum, palladium and rhodium sponges was evaluated. The solubility values can provide useful insight into probable separation/recovery strategies from spent catalysts. A simplified flask method from Organization for Economic Co-operation and Development (OECD) Guideline 105[2]was used in this case to determine the water solubility of these PGMsponges using ultra sonication followed by Inductively Coupled Plasma-Optical Emission Spectrometric (ICP-OES) analysis of the PGM content. The results provided reliable data on the solubility of these metal sponges previously unavailable in the literature[1,2].

Keyword

Platinum Group Metals, OECD, ICP-OES

Introduction

Vehicular exhaust emissions are one of the major sources of air pollution. To limit these pollutants e.g. CO, HC, NO_x, the emission standards, based on European regulations were first introduced in 2000. Progressively stringent norms have been laid out since then[3]. All the new vehicles manufactured after the implementation of the norms have to be compliant with the regulations. In 1996, there was a revision of the mass emission norms for petrol and diesel

vehicles, and the fitment of a catalytic converter was mandatory. Currently BSVI norms are applicable all across India which demands a very high level of pollutant control in the after treated emission gases

A catalytic converter contains precious metals such as palladium, platinum, and rhodium in order to convert harmful gases emitted from vehicle engines to relatively harmless ones by reduction of nitrogen oxides (NO_x) into nitrogen N_2 and the oxidation of hydrocarbons and CO to CO2.Depending on the type of engine and application, the architecture of the catalyst with respect to concentrations of PGMs in the unit vary widely. In recent car catalytic converters, Pt, Pd and Rh concentration ranges from 300 to 3000 mg/L; In all cases, the percentage of total content of PGMs in the samples are less than 0.5%.

There is an increase in demand of these PGM out of the total general demand for these metals[4] (Figure 1, Table 1). While Palladium and Rhodium automotive catalyst demand is the biggest share of the overall demand (>80%), the Platinum automotive catalyst demand is 35% of the total demand

PGM	2018-2020		
	Pt	Pd	Rh
Total Demand (kOz)	23307	31663	3203
Automotive Demand (kOz)	8099	27045	2833
% of Total Demand	35	85	88

(Source: PGM Market Report 2021, Johnson Matthey)

Table 1: Pt, Pd, Rh share of the automotive catalyst demand from 2018-2020.

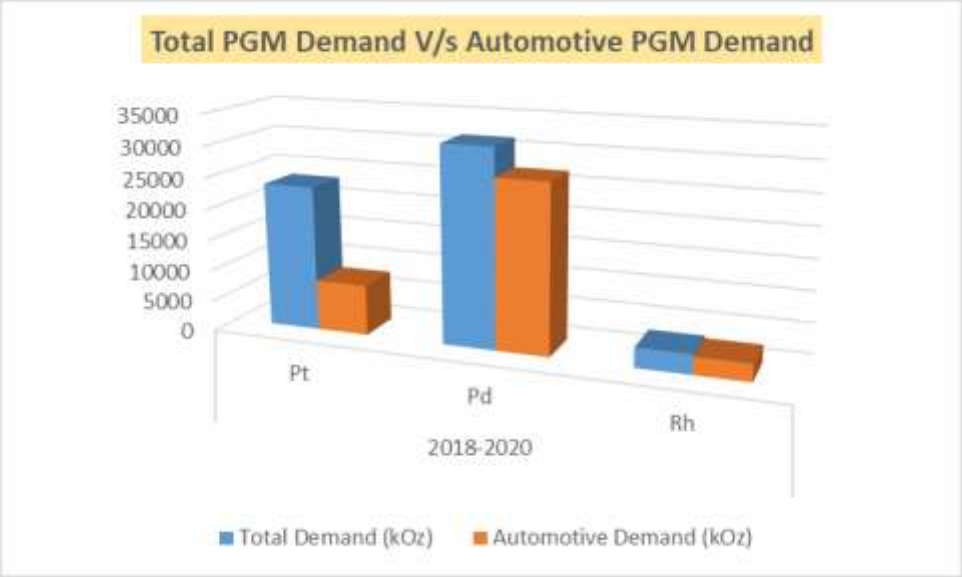


Figure 1: Comparison of the general demand of the PGM metals and its demand in the catalytic converter industry[4]

Thus, to cater to the general demand and low supply of the raw PGMs,there arises the need to recycle these precious metals to alleviate expensive and energy intensive mining and, in the process, avoiding negative environmental impact. Moreover, another motivation to recycle the spent catalytic converters is the high monetary values and quantitatively low availability and supply of the raw PGMs.

There are many separation processes available with respect to extraction of precious metals from spent catalysts. However, as the years are going by, we are moving towards electrical vehicles and greener ways of production. The most ideal way to separate the metals would be through specific precipitation using their solubility products because of its inherent simplicity and without the need for using expensive extracting agents and stripping procedure thereafter.

The solubility product constant, K_{sp} is the equilibrium constant for a solid substance dissolving in an aqueous solution. It represents the extent to which a solute dissolves in solution. The more soluble a substance is, the higher the K_{sp} value it has at a given temperature.

The water solubility's for 22 PGM salts and complexes were determined by Matt Gregory[1] as per the OECD Guideline 105. Our present work focuses on obtaining a comparative estimate

of solubility product differences of all three PGM sponges– Platinum, Palladium and Rhodium using the OECD flask method[2] using a simple experimental setup. This will help us to further design an appropriate precipitation strategy to separate the PGM selectively to enable recovery from the spent catalyst.

Materials and Instruments

1. Furnace (850 °C)- Nebartherm Make Temperature Range up to 1100 °C with variable ramping options
2. Ultrasonicator–PEI make (40Hz)
3. MilliQ DI Water – Conductivity 1.27µS/cm (at 25 °C)
4. ICP OES- Agilent 5800 series

   Power: 1200kW

   Nebulizer gas: Argon

   Nebulizer flow: 0.5-0.7 L/min

   Auxiliary flow: 1.0L/min

   Pump Flow rate: 12 rpm

   Detector view: Dual

   Calibration Range:

Standard	Pt (ppm)	Pd (ppm)	Rh (ppm)
Blank	0	0	0
Std-1	1	1	1
Std-2	10	10	10
Std-3	20	20	20

Table 2: Calibration Mix

5. **NIST traceable standards** -1000ppm each for Platinum, Palladium and Rhodium for preparing the calibration mix (Table 2)
6. **pH Meter**: Analab make with ready to use traceable pH standards 4.0 /7.0 / 9.2
7. 10-15% w/w Platinum Nitrate, Palladium Nitrate and Rhodium Nitrate solutions – Heraus make- used without further purification

Experimental Details

2gm of each PGM solutions (Platinum Nitrate, Palladium Nitrate and Rhodium Nitrate) are weighed in a silica crucible and ignited at 850°C to yield corresponding PGM sponge (refer figure 2 showing palladium sponge).An approximate indicator of the solubility is provided by Test No. 105: Water Solubility;OECD[2]given in the table3 below

0.2 g of sponge was added to 20 ml of deionized water (MilliQ water -1.27µS/cm at 250°C) in three different conical flasks corresponding to sponges derived from Platinum nitrate, Palladium nitrate and Rhodium nitrate respectively. The flasks were stoppered tightly and ultra-sonicated at 40Hz frequency for 1 min at 30°C. After 24 hours the solutions were filtered using 0.1 µm membrane filters and the PGM content was determined by ICP-OES. The pH of the solution was also measured (Table 3). The analysis was repeated for each material to provide duplicate data.

Figure 2: Palladium Sponge

Results and Discussion

The water solubility reported by Matt Gregory[1] using the shake flask method as per the OECD Guideline 105 for a variety of PGM containing salts, but the comparative solubility for a similar salt /moiety of the PGM is not available. The present experimental setup is designed to compare the water solubility's for PGM metal sponges. Here to ensure uniform shaking ultrasonic frequency and sonication time was kept same for all three sponge samples to ensure less variability as compared to manual shaking.

The Linearity of the ICP calibration with the calibration mix (Table 2) was verified first prior to analyzing the filtered samples. The correlation coefficient of calibration in each of Platinum, Palladium and Rhodium was >0.9999 which is adequate.

The filtered samples were analyzed and the ppm of the metal content obtained in the filtrate was converted to g/L (water solubility). The pH of these filtrate solutions was also measured by a pH meter calibrated by pH Buffer 4.0/7.0/9.2

The results of the analysis are tabulated in Table 3

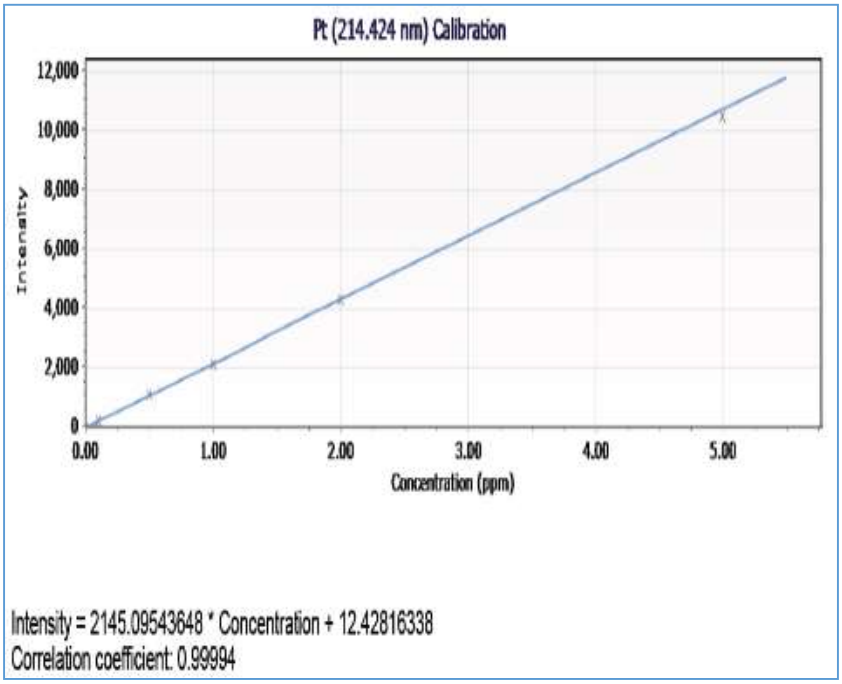
Compounds	**CAS No**	**ppm in filtered sample**	**Water Solubility g/L**	**pH**
Palladium Sponge	1314-08-5	0.06	$6X10^{-5}$	5.03
Platinum Sponge	1314-15-4	1.1	$1.1X10^{-3}$	3.38
Rhodium Sponge	12036-35-0	6	$6X10^{-3}$	3.93

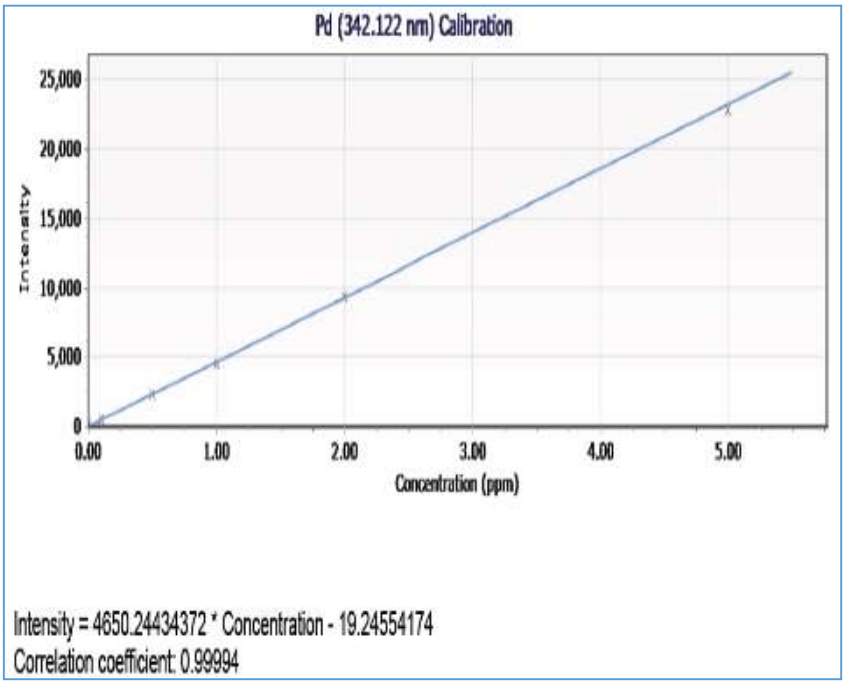
Table 3: Analyzed water solubility and pH of PGM sponge in DI water

A distinct trend in the water solubility's of these metals could be obtained where Platinum sponge has the highest water solubility while Palladium sponge has the least water solubility. The pH of these filtrate solutions was analyzed to check for differences due to the various PGE's and shows a distinct relative basicity of the Palladium sponge in comparison to the Platinum and Rhodium sponges (Table3).In the actual catalytic converter, however, the PGM metals are anchored on a solid support material on the honeycomb structure after calcination and converts emission gases based on solid state chemical reactions between solid and gaseous interaction, hence will not leach out. The leaching out process may require strongly oxidizing conditions such as aqua regia[5], attrition scrubbing[6] and does not simulate the situation at the gas-liquid interface of the engine exhaust. The extraction of PGM sponge in acidic solution (DI water after acidifying) was therefore not in the current scope of the work.

As observed above, the calibration range was very broad compared to the water solubility's (concentration of platinum, palladium and rhodium analyzed) in the samples, hence a narrower calibration range from 0 to 5ppm was made to enhance the detection accuracy and reduce the errors (% RSD).

With the narrower calibration range the % RSD was found to be reduced to about 2 -2.7% which was earlier nearly 5% (for Palladium and Rhodium). Also, the correlation coefficient was also consistent (Figure 3)





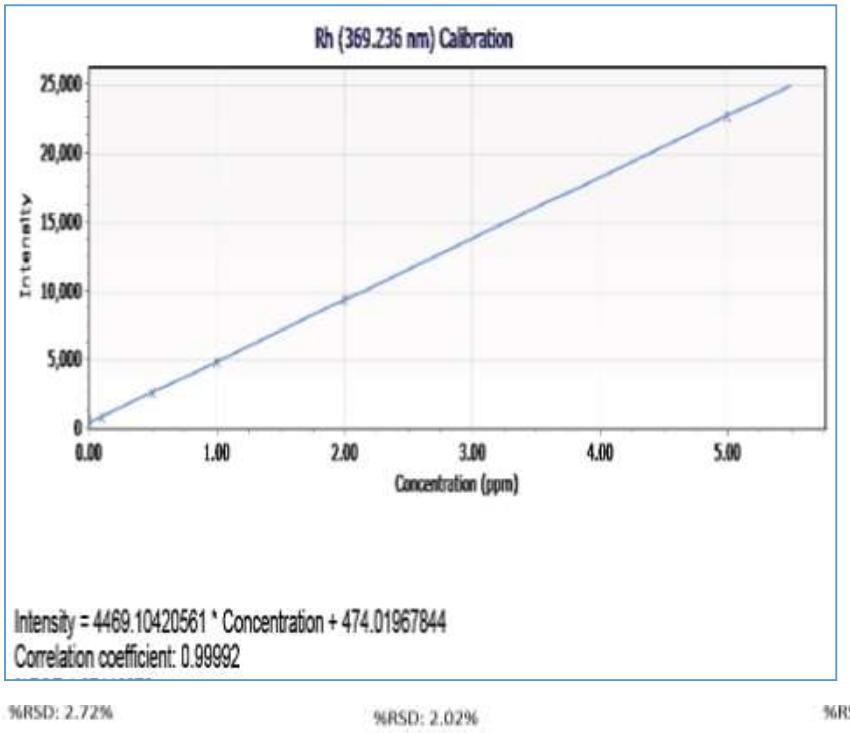


Figure 3: Linearity plot of Intensity v/s Concentration–Pt, Pd and Rh – narrower range with correlation coefficient & error

A second set of water solubility trial was undertaken with fresh sponge samples and the results are tabulated in Table 4

Compounds	CAS No	ppm in filtered sample	Water Solubility g/L	pH
Palladium Sponge	1314-08-5	0.09	$9X10^{-5}$	5.06
Platinum Sponge	1314-15-4	1.79	$1.8X10^{-3}$	2.82
Rhodium Sponge	12036-35-0	4.89	$4.9X10^{-3}$	2.97

Table 4: Analyzed water solubility of PGM sponge in DI water with narrower calibration range and pH of the filtrate

The same trend of water solubility's could be obtained where Platinum sponge has the highest water solubility while Palladium sponge has the least water solubility. Also, similar trend of pH observed as in the first trial.

Conclusions

This investigation has provided reliable water solubility data for a range of PGM sponge previously unavailable in the literature and is required to convert PGM sponge into the solution form before it is being used in manufacturing of Catalytic converter. A range of PGM sponges were analyzed for water solubility. Each substance was measured in duplicate and compared. The flask method according to OECD 105 guideline was used for the oxide samples. From the experiment it is clear the water solubility of the sponge is of the order Pt >Rh>Pd.

This investigation has provided reliable water solubility data for a range of PGM sponge previously unavailable in the literature. Measurement of solubility is of paramount importance as losses in PGM due to inadequate solubility or less recovery will not only lead to resource as well as economic loss. In addition, this can form the basis for selective precipitation strategies for PGM recovery from waste catalysts especially Pd (due to two orders difference in solubility) from Pt and Rh without resorting to the use of expensive extracting agent.

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