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Decision Making As an Individuating Process

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ABSTRACT:*This paper is based on the premise that probabilistic judgements made under a context are often individualistic and are rationalised with respect to the information under consideration. It is believed that the processes and the knowledge that students bring while making decisions in real life contexts are far more profound and complex and thus need contemplation. In this paper an attempt has been made to understand how students conjecture their decisions by amalgamating and interpreting from the information available with them. In particular, the paper delineates how students' decision making is an individuating process, dependent on the facts in consideration.*

KEYWORDS: *Decision making, Probability Awareness, Contextualised situations, High- school students*

I. BACKGROUND

Indeed in our daily encounters we often have to deal with situations soliciting decisions. Situations that involve risk, chance, predictions, uncertainty, such as, predicting the chances of rain, deciphering the results of a medical report, articulating the chances of winning a game, investing money in an insurance company are some of the situations where a prediction and, subsequently, a decision is required. Given this pervasiveness of uncertainty, it is important that we are prepared to face the challenges of managing risks, facing events of chance and optimizing decisions regarding uncertainty.

Moore (13) and Utts (16) understand probability as making informed judgements on uncertainty which implies we need skills that are far more complicated and profound than throwing a dice or tossing a coin or drawing balls from an urn. To be able to develop probabilistic thinking it is not enough to have the knowledge of the mathematical content alone. It rather involves an ability to make assertions that are rational (6,7). Being probabilistically aware does not confine to the calculative aspect of doing probability, it instead include an ability to interpret chance and uncertainty encountered in real-life situations and to make judgements which can very well be influenced by the context in which they are made. 'Understanding probability encompasses the mathematical knowledge and dispositions that people may have to develop to be considered literate regarding real-world probabilistic matters', (6). These views of interpreting probabilistic awareness depend upon how predictions and decisions are made under real-life circumstances. When we encounter any situation where a prediction or a judgement has to be taken we not only depend on the structure of the situation but also on a variety of information that may have underplayed a crucial role in the fortification of the situation. When we try to comprehend uncertainty we try to make our best possible assertions by amalgamating the information, explicitly or implicitly present in the situation, along with our prior experiences (6). Cosmides and Tooby (2) assert that probability judgements are the ability to individuate the world. Extending these views further, it is noted that as people encounter decision making situations in diverse contexts, subjected to their previous experiences and beliefs, their interpretation of the situation are often governed by their idiosyncratic and subjective knowledge. Being probabilistically aware, thus, would encompass analyzing the context, synergizing both explicit and implicit information and making reasonable assertions. This means we make our subjective predictions depending upon a variety of factors which are often individualistic.

Taking cognizance with the above views many researchers and mathematicians have tried to understand how people make judgements in uncertain situations. Several studies have tried to look at the relationship between the natural, intuitive approaches that individuals hold with regard to probabilistic situations (3, 4, 5, 12) and how a coherence can be established from the nascent, intuitive understandings to a formal probabilistic construct (10, 11). These studies have tried to unravel the notions that people may have of a particular probabilistic construct and the possible (mis)conceptions that they hold when they encounter an uncertain situation. In their seminal work Kahnemann, Slovic, and Tversky (12) noticed that when making judgements under uncertainty people do not appear to follow the calculus of chance or the statistical theory of prediction. Instead, they rely on a limited number of heuristics which sometimes yield reasonable judgements and sometimes lead to severe and systematic errors. These studies establish that when making judgements regarding uncertainty people may not accord to the calculus of probability. While such studies contribute

towards the extension of understanding the 'formal' concept of probability, they lack in deliberating on the idiosyncratic knowledge generated as a result of interplay between the peoples' dispositions, knowledge of the event and prior experiences that play a pivotal role when making judgements.

Another addendum to the concerns of probability is to understand how people make decisions in real-life, in-situ. To take a decision is a complex activity as it is closely linked to people's ability to think carefully about the decisions they will have to make. Gregory (8) emphasized that decision making is beyond doing rote memorization and routine problems. When making a decision we need to do something beyond rote memorization or rehearsals of fact. This activity calls to do more: to seek additional information when it is needed, to recognize inconsistencies in problem formulation, to evaluate the truth of claims made in a statement or text, and to combine information and techniques in ways that are not exact parallels of previous situations (8). Making decision thus encompass the challenges of interpretation, analysis, or manipulation of information, because the question to be answered or the problem to be solved cannot be resolved through the routine application of previously learned knowledge (14).

Yet another challenge that plays a crucial role in our decision making is the divide between the generator and the user of the information. Research abounds with studies where either stimulated tasks or problem solving situations are provided to know how people make decisions in uncertain situations (9). In most of these studies some information is provided to the students and then they are expected to make decisions based on the information provided. The basic assumption in such work lies in considering students as consumers of information. Students who are the decision makers are not in-fact information generators and so it creates a divide in terms of the information provider and information consumer. Beyth-Marom (1) establishes this as 'division of labour', one person or organization provides the information while another makes the decisions. Thus, for any decision to take place it is necessary that there is a clear communication between the information provider and the decision maker. A necessary condition, therefore, to become effective decision makers is to break this divide between information generators and information consumers.

Such concerns bring forth some fundamental questions: how prepared are our students, after completing their formal education, in taking decisions on real-life situations that they would commonly encounter? Does the content of probability, as taught in schools, provide enough acumen to our students to gauge and take rational decisions on day-to-day situations? It is noted that within the rigid school system students quite often are not exposed to the skills to making probabilistic judgments which are expected under real life contexts. Noddings, Gilbert-MacMillan, & Lutz (15, as cited 8) have confirmed that students often get entangled in a 'number-crunching' mode and try to plug in quantities without forming an internal representation of the problem. We are thus urged to examine if our students, having studied probability and statistics as part of their formal school math course, are prepared enough to face the challenges of real life probabilistic situations and make rational decisions in a world beyond text books.

There is a need to understand how students use information, make connections and rationalize their decisions on a fortuitous event, which is often beyond the typical problems usually found in text books. To facilitate the skills of seeking relevant information, organizing the information and making rational interpretations we need to provide engaging tasks that are embedded in a context.

Summating the above concerns, in this research an attempt has been made to understand the mechanisms by which students use the information, as available in real life, to make their judgements under uncertainty.

Following made the rationale of the study:

a) Students are often not exposed to the skills to making probabilistic judgements under real life contexts.
b) There is a need to understand the processes that facilitate decision making in real life situations.
c) To make decisions we need to provide students with the challenges of finding the relevant information, organizing it, analyzing it, interpreting from it and finally using it to make decision.
d) Often decision makers are not information generators, thus there exists a divide in terms of the information provider and information consumer. It is, therefore necessary to break this divide and help students to become better decision makers.

In this study, conducted with students who had just completed their grade XII i.e formal schooling, a contextualised situation was given to understand how they make predictions regarding the situation. To help them base their conjecture they were given the freedom to decide the type and extent of the related information they would need. Subsequently, a comparison of the trajectories made by two groups of students (four students comprised a group) in selecting, organizing and interpreting the information for making their decision was studied in detail.

II. THE STUDY

The study was conducted with 16 students from Indian schools who had just finished their formal school education i.e. had just completed grade XII. In a typical Indian school the age range of students studying in class XII is between 16-17years. Since mathematics is an optional subject in class XII, only those students who had studied mathematics throughout their schooling years were invited to participate. So, the students who participated in the study had studied mathematics till their high school level.Initially 40 students were introduced to the study and after giving a short introduction only the students who volunteered to participate were finally considered. 16 high school students finally volunteered to be a part of the study. These students were randomly divided in 4 groups of 4 students in each group.Based on the premise of knowing how students, who have studied mathematics (and probability) for certain years make decisions in real life situations, an appropriate real-life situation, that would come close to their experience was chosen. A questionnaire comprising of four questions in probability was given to the students. Three out of these were routine problems, commonly found in any Indian class XII mathematics textbook but the fourth question, which also made the target task for this study, was based on predicting a winning team for a cricket tournament.

The target question was:

> *If four cricket teams, lets say Team Ace, Team Bold, Team Chargers, Team Daring and Team Effective participated in a cricket tournament, what is the probability that Team Bold will win the tournament.*

Though the questionnaire had four questions in all, only the responses given to this target question were considered as part of this study. This question was the axis of the study. The subsequent discussions will be based on the responses and work done by the students on this target question.Initially, each student had to answer all the questions individually. Afterwards the rest of the work was done in small-group situations (four students in a group). Each student worked collaboratively in his/her respective group.

III. RESULTS AND ANALYSIS OF DATA

This section attempts to elaborate on the trajectories that two groups followed to reach their decision on the task in focus. It was noted that all the four groups had their individual and a different trajectory towards their assertion. However, in this paper the trajectories of only two groups will be discussed. Special attention was given to the ways in which the students of both the groups worked collectively to reach their decision. The type of information sought by the students, their strategies of connecting the information, inferences that they drew from the facts and finally their path towards evolving a criteria, based on which the final decision was taken, were observed in details.With each group three meetings were held. Discussions in each meeting were focused towards the targeted task i.e. predicting the team that could have possibly won the cricket tournament. Though there was no time limit for the duration of the meetings, it was observed that the first meeting, across all the groups was the shortest, lasted for an hour. As students started evolving their solution paths the meetings tend to become longer. The last meeting with all the groups was the longest and lasted for approximately three - four hours duration. In each meeting some special episodes were observed and due to these each meeting has been earmarked as a phase. It can be said that in all there were three phases and each phase can be identified by the dominance of a particular activity that took place in that phase. Given below are the details about the three phases and the trajectories that the students, in their respective groups, adopted leading them towards their decision.

III. 1 Phase I: Calculative Dominance

After the students responded to the questionnaire as an individual exercise, it was observed that in the target task (the cricket problem) all the students gave a similar response. ‘Since there are five teams, therefore the chances of a particular team to win are 1/5’. Probing further, when asked to explain, all students in all the groups claimed that since there are five teams and only one team wins the tournament, the probability of each team is equal i.e. 1/5.

These responses reveal the dominance of a calculative instinct over the context. It shows that the calculative urge, to give a numerical answer, prevails. For students, all the playing teams have equal probability of winning. They regard the performance of all the teams as equi-likely, therefore any of them could be a possible winner. In a way, the cricket tournament embodies the same structure as picking balls from an urn. For them all the teams were equi-probable and equi-likely and so no external conditions mattered. This reflects a limited exposure to the probabilistic situations as experienced in real - life contexts. For, in real life the events may not necessarily be equi-probable and also are not as 'neat' as presented in textbooks.

III.2 Phase II: Seeking information

The second phase can be recognized as an information seeking stage. It is at this stage onwards that each group diverted in their strategies of looking for the relevant information, sequencing it, interpreting and making connections within the data and using it to formalise their conjecture. This phase gave enough freedom to the students to ask for whatever information they needed that could help them base their decision. Students worked in their small groups to list the data that they required to support their work. It was noted that the students not only sought for the information but also decided the format in which it should be presented. As the requirements of each group varied, it was the task of the researcher to ensure that all the data asked by the groups be provided and presented to them in the exact format in which it was asked. For example, if Group A wanted the list of batsman of each team they were provided with that particular information and if Group B required only the batting order of the players it was ascertained that only the order of batting was provided to them. Table 1 gives the list of information sought by Group A and Group B.

Group A	Group B
List of Players in each team	Batting order of each team
Past two years record of each team	Past record of each batsman
List of good batsman, bowlers and all rounders of each team	Past record of each bowler
Average scores of batsman and bowlers of each team	Past performance of the coaches of each team
Sequence of matches played between each team	Information of matches played at home-grounds
Matches played in the home-ground of the teams	
Pitch type of each stadium in which the matches were schedule	

Table 1: List of Information

As the students decided and calibrated the type and format of the data, it can be said that in this phase complete independence was given to the students to decide on the content and the extent of information that they required. By giving them this opportunity the students were no longer consumers of the information, they were rather, the generators of the information based on which they were to make their decision. Thus, one can say that in this stage students were not consumers but producers of the information as the information consumer was not different from the information seeker. This stage also gave them the opportunity to work in their groups wherein they consulted each other to device their own ways of connecting the information and using it according to their need. This phase gave them the autonomy and responsibility for deciding the criteria they wish to consider. They recognized the relevance of each data and thus had more responsibility to use the asked information judiciously. It was noted that the students questioned, argued and convinced each other on the type and extent of information needed. This also reflected their alertness to avoid redundancy of the information.

III.3 Phase III: Using information for decision making

The third phase is earmarked by the activities that the groups followed to base their decision. The students in this phase used the information, asked by them, to make connections and interpretations to reach their conclusion. Since both the groups sought for different information they followed different trajectories for making the decision. In this phase students were seen as generators of their decisions.

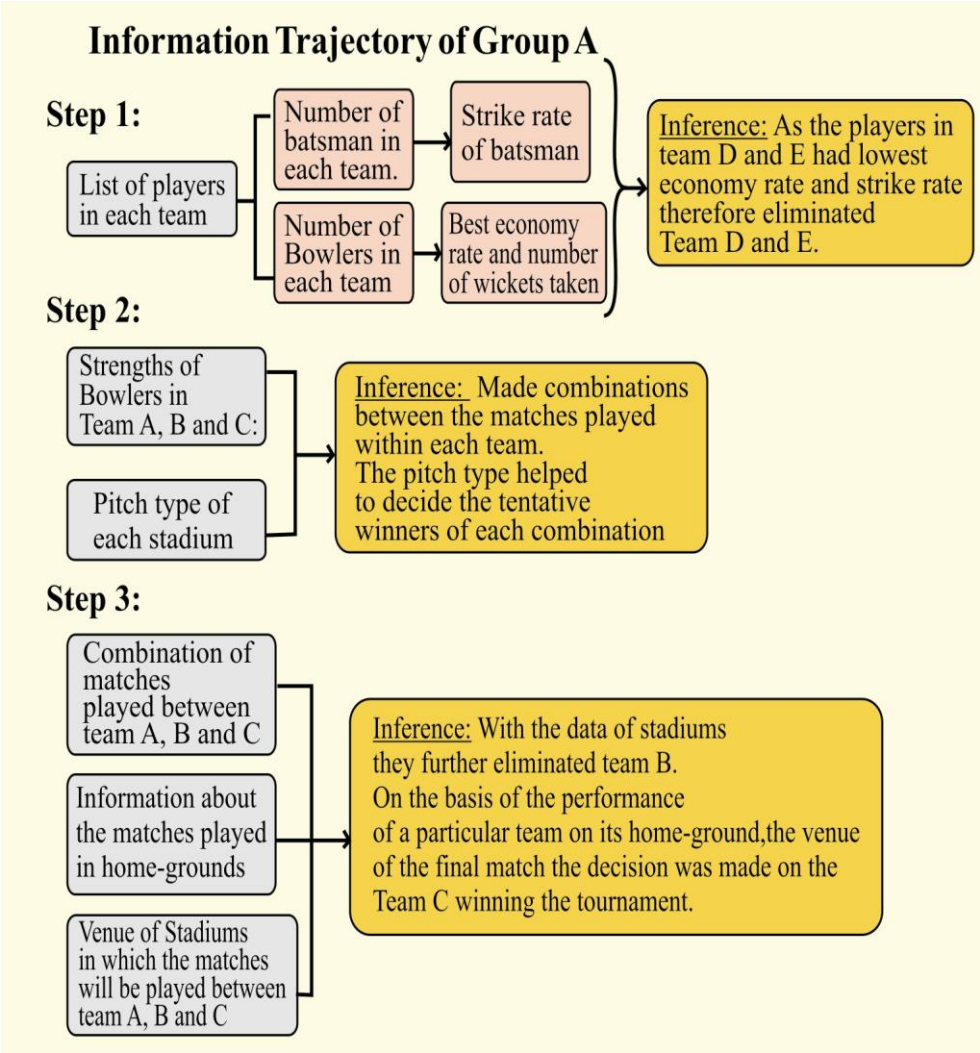

Figure 1: Information Trajectory of Group A

Fig. 1 gives the trajectory that Group A followed to reach their decision. Group A followed a stage wise elimination process to reach their decision of the team that had the possibility of winning the tournament. They used their information in chunks and followed an elimination strategy. For example, they started their work by considering the players playing in the respective teams. To this they combined the past records of each player, such as the number of batsmen, the number of bowlers in a team, average strike rate of each batsman and economy rate of the bowlers. On the basis of this information they made their first elimination. The information helped them to conclude that the players (both batsmen and bowlers together) of Team D and Team E were the weakest as these teams did not have impressive previous records. This led to the elimination of both Team D and Team E from the tournament, as a first step. Subsequently, they used other information like strengths of bowlers in the remaining teams and the type of pitch to make inter-team combinations and to infer the winning team from these combinations. Finally, by using the information about the venue of the matches and winning record of a particular team on its home-ground they eliminated Team B and Team A to conjecture that the possibility of Team C being the winner of the cricket tournament as highest.

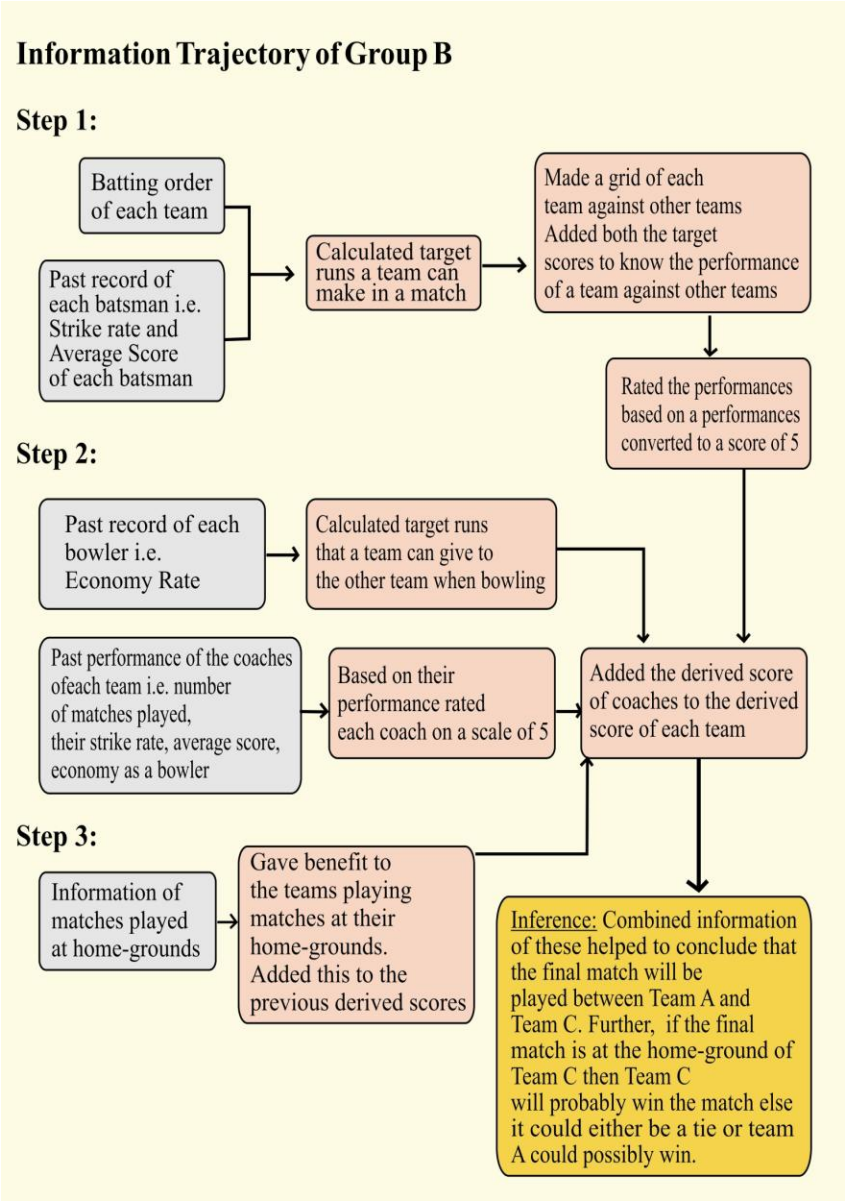

Figure 2: Information Trajectory of Group B

Unlike Group A, Group B followed a rather more quantitative approach to base their decision. Fig. 2 illustrates the trajectory followed by Group B to reach their decision. They did not make any sub-stage conclusions based on piecemeal facts. They rather used all the information asked by them and thought of deriving a common basis for all teams before making their decision. For example, they started by considering the batting order of each team and the previous records of each player. Using the previous performances of the batsmen they calculated a tentative target score that each team could possibly make given that the fixed number of balls usually played in a match of fixed number of overs. To this tentative score they added the scores that each team could possibly give to its opponent as bowling team and reached a projected score. They used these projected scores for all the possible inter-team combinations. Further, they considered the past records of the coaches of the respective teams. They rated the coaches of all the teams and subsequently added this rated score to the respective team's projected score. Finally, they used the information about the nature of the pitch and past performances of each team on these grounds. From these past records they realized that the team playing on its home ground usually benefited. Thus, they rated the benefit that each team could get if it played on its home ground.

All the projected scores were finally added to infer, quantitatively, about the strengths and weaknesses of each team's performance. In their next stage they made inter - team combination matches in a 5x5 matrix that reflected all the possible inter-team match combination and the projective score of each team as opposed to its opponent. The combined data helped Group B to predict that both Team A and Team C were equally strong as numerically both the teams projected the same score. The group predicted that Team A and Team C could possibly contest against each other in the finals and depending upon the venue of the final match any of them could be the winner of the tournament.

III.4 Comparison of the trajectories of both the groups

Though both the groups had accounted for the similar information, their hypotheses and processes of conjecturing were quite different. They followed different trajectories to base their decision. Group A gave emphasis on eliminating the teams on the basis of their past performances. They considered the information in a piece-while manner and followed an elimination strategy. Rather than considering all the information together they used the information in chunks to eliminate the weaker teams and subsequently narrowing their choices. Group B, on the other hand, followed a more systematic procedure of using all the information and calculating a projective score. They quantified every fact to calculate a projective score by considering all the available information. They rationalized each data by systematically converting the information to a projected score for a common comparison. They gave logical arguments by considering all possible combinations before finalizing on any one. This also reflects that Group A concentrated more on individual players while Group B concentrated more on each team's performance as a whole.

IV. CONCLUSION

Acknowledging we are surrounded with statistical and probability messages, it is important that our students, after completing formal years of schooling, are at least familiar with the challenges of understanding, interpreting and making decisions in probabilistic contexts. The recent challenges of 'probability literacy' (6) had put forth pertinent issues of recognizing how well can students discern the functional aspects of a probabilistic situation i.e. can the students reason, argue and analyse a probabilistically laden information? What factors do they consider when taking decision? How do they authenticate their decisions, taken under some constraints?In this study an attempt has been made to understand how humans make probabilistic judgements when they encounter situations close to their experiences. It is indeed daunting to understand how people make decisions when a variety of information underplays a crucial role behind its fortification. Research on how people individuate the world is, therefore, relevant in understanding the mechanisms that govern their conjecture making. People derive individual and personal predictions under uncertainty and this was evident by the processes the students followed in seeking the relevance of each data and connecting it to reach their prediction.

Since when conjecturing on the fortuitousness of an event students had depended on different types of information, their probabilities were subjective and in a certain sense even personal. Depending upon personal hypotheses of what is reasonable, probabilistic judgements can be termed as individualistic as they lead to conclusions which are rational within the peripherals of the information in context. Different people can draw entirely different conclusions for the same event, depending on the extent of information sought or available. Noticeably though, are the processes by which we make such interpretations. These interpretations are often made by sequentially filtering the relevant information and then optimizing the decision within the peripherals of the existing constraints. Thus, to make any decision we depend upon a) the information available b) our previous experiences and c) dispositional factors. Since these factors are subjective therefore decision making is subjective, even individualistic.

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