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Electrical Conductance Measurement of Mixture of Cationic and Anionic Surfactant and Statistical Interpretation

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Abstract

Investigations on the Physico-Chemical properties of mixtures of surfactants are fascinating and useful in detergency, cosmetics, pharmaceutics and industrial fields. Mixed surfactants are of great importance because of fundamental interest as well as extensive scientific and technological applications. An attempt has been made to undertake the investigation on the measurements of electrical conductance of aqueous solutions of NaDC and CTAB and their mixtures as functions of concentration and temperature.

Keywords: *Surfactant, NaDC, CTAB, Micelle, Conductance, Cationic, Anionic*

1. Introduction

A surfactant is briefly defined as materials that can greatly reduce the surface tension of water when used in very low concentrations. Surfactants perform a particular type of molecular structure. Surfactant is abbreviation for the term SURFACE-ACTIVE-AGENT which means activity of an agent or a substance on surface. The surface can form between solid and liquid, air and liquid or liquid-liquid phase.

Surfactant molecules have two distinct parts: one that has affinity for the solvent and the other does not. In aqueous solutions these two moieties are hydrophilic and hydrophobic respectively. It is the tendency for the hydrophobic parts of the molecules to aggregates because of mutual dislike of the solvent which is the driving force for surfactant self association. However our major interest, because of their wide spread occurrence in natural, industrial and domestic areas, is in systems where the liquid phase is water. Surfactants are amphiphilic materials and are employed in industrial applications such as pharmaceuticals, polymerization processes, detergency, foods and enhanced oil recovery (Leontidis- Kyprianidou et al., 2001; Jones, 1992; Wang, 1995; Dutta, 1988; Evani, 1987; Thatberg, 1989). In most biological and industrial applications mixed surfactants are employed because they can enhance the behaviour of a single surfactant (Purdhomme, 1984; Scamehorn, Schechter &

Wade, 1982). Also, additives such as polymers alter the surface tension and the rheological properties. When surfactants are dissolved in water, they concentrate at the surface, where by orient in such a way that their hydrophobic groups are directed away from the water, the free energy of the solution is increased. Depending on the nature of the hydrophilic group, surfactants are classified as anionic, cationic, non-ionic and zwitter-ionic.

The properties of ionic surfactants are parallel to those of the strong electrolytes in dilute aqueous solution, nonionic on the other hand resemble those of simple organic compounds depicting at high concentration pronounced deviation from ideal behaviour of dilute solution. The word micelle is a Latin term meaning 'small bit' and was coined by J.W. McBain (McBain, 1920) in 1920 to describe colloidal sized particles of detergents and soaps, and the phenomenon of self association of monomers into micelles was called micellisation. The driving force behind micellisation, the hydrophobic effect was proposed by G. S. Hartley 1936 (Hartley, 1936). He also suggested the roughly spherical model for the micelles, suggestion that gained general favor later. The concentration at which micelles first appear in solution is termed as critical micelle concentration (cmc) a term proposed by Bury and Davis (Rosen, 1989; Jones, 1927) in 1930. The cmc is the single most important characteristic of the surfactant. Among the properties that have been used in determining the cmc are surface tension, electrical conductance, density, sound velocity, viscosity, solubilization and NMR chemical shift etc.

The cmc is determined experimentally from the inflection points of any physical property of the solution against concentration. The change of physical properties at the cmc occurs over a narrow concentration range rather than a precise point and the magnitude of this range depends somewhat on the physical property (Rosen, 1989). Investigations on the Physico-Chemical properties of mixtures of surfactants are fascinating and useful in detergency (Durham, 1961; Jaeger, 1993; Prescstt, 1963), cosmetic (Prescstt, 1963; Ward, 1964; Hannan, 1978), pharmaceutics (Ali, Botton & Gaylord, 1991) and industrial fields (Kilan, 1991; Somasundaram, 1985; Somasundaram, 1985). Mixed surfactants are of great importance because of fundamental interest as well as extensive scientific and technological applications. The characteristic behaviour of mixtures containing surfactant and polymer is of increasing interest because of their relevant capacity such as viscosity modulators, of their ability to control surface

adsorption and of their solvent capacity towards fats and oils (Goddard & Ananthapadmanabhan, 1992; Kwak, 1998). It has been found that the solid-liquid interface plays an important role in many industrial processes such as detergency, floatation and drinking. In many of these applications the use of surfactant mixtures improves significantly the performance over those of single component system (Kilan, 1991; Somasundaram, 1985; Somasundaram, 1985; Goddard & Ananthapadmanabhan, 1992). The mixing of cationic and anionic surface active agents give rise to the formation of rods, vesicles or precipitation depending on the relative amounts of the component (Hao, Hoffman, & Horbaschek, 2000). Significant results along this line have been obtained by mixing ionic and non-ionic surfactants and/or modifying the pH which have been proved very useful in forth-floatation. The Physico-chemical properties of aqueous solution of mixed surfactants will change as the concentration increases and aggregates forms. The micelle is composed of both the surfactants in equilibrium with the monomeric species in the aqueous phase. It has been observed that anionic surfactants typically react more strongly with additives than cationic surfactants (Puvvada, 1992; Sierra & Rodenas, 1993). The characteristic properties of some synthetic, ionic and non-ionic surfactants in aqueous solution in pure as well as in mixed state in absence and in presence of additives may be studied as functions of concentration and temperature. The coexistence of such peculiarities in the same system offers the opportunity to tune the required properties by changing the polymer, the surfactant, and/or their ratios. These possibilities open the way to several formulation procedures and to the preparation of fine chemicals for personal care and the pharmaceutical industry (Holmberg, Jonsson, Kreilberg & LindmaIl, 2002; Almgren, 2003; Zana, 2003).

The intrinsic theoretical interest and extensive uses in diverse areas of biological, pharmaceutical and industrial worlds, in depth information on the surfactant solutions are considered extensively important prerequisites (Rubingh & Mittal, 1979; Rosen, 1989; Haque, Das & Moulik, 1995; Moulik, Haque & Jana, 2000). Combination of surfactants and polymers normally leads to the formation of mixed miceller aggregates. Such mixtures are of much in1portance since they frequently exhibit a behaviour that is quite different fron1 that of the individual surfactant systems. The interaction between different surfactants may results in synergetic or antagonistic effects depending on the precise nature of this molecule (Rosen, 1989; Haque, Das & Moulik, 1995; Moulik, Haque & Jana, 2000). Most-studies on polymer-surfactant systems deal with Sodium Dodecyl Sulphate

(SOS) and single chain compounds (Curbane & Duplessix, 1982; Ibid, 1978; Meszaros, Thompson, Bos, Varya & Gilani, 2003). The results reported so far allow for constituent explanation of polymer-surfactant interaction (PSI) in terms of molecular properties of the surfactant and the polymer (Ortona, Derrico, Paduano & Sartori, 2002; Roscino, Asaro, Pellizer, Ortoina & Paduano, 2003). When a polymer is employed as an additive, the surfactant- polymer interaction depends upon several factors such as the nature of the surfactant head group, the nature of the polar groups embedded in the polymer backbone and the polymer hydrophobicity (Brackman & Engberts, 1991). With cationic surfactants besides the electrostatic interaction between the polar head groups of surfactant and neutral polymer the respective hydrophobic interactions also play a significant role in determining the surfactant- polymer interactions (Goddard, 1986; Garcia-Mateos, Perez & Valazquez, 1997; Brackman & Engberts, 1987; Winnik, Winnik & Tazuke, 1987).

In the mixed micelles, these interactions are also affected by the variation in the composition of the binary mixtures. Neutral polymers have been observed to interact with surfactants. Often, these interactions exhibit characteristic polymer induced self-aggregation at a concentration called the critical aggregation concentration (CAC), lower than the critical micellar concentration (cmc) of the surfactants (Lindman & Thalberg, 1993; Chari & Lehhart, 1990; Berkhira & Franta, 1994; Fox, Bloor & Holzwarth, 1998). The interaction between cationic and non-ionic surfactants and protein has received substantially less attention than the anionic ones. The non-ionic surfactant Triton-X-100 has been shown to undergo limited binding with proteins; although there was little evidence for sufficient interaction to induce the conformational changes found in the case of anionic materials (Makino & Reynolds, 1973). The phenomenon of mixed micelle formation was proposed by Clint (Clint, 1995) with the help of phase separation model.

The most common theoretical description of the micellization behaviour of p^H sensitive surfactants (and of binary surfactant mixtures in general) is the regular solution theory (RST) (Holland, P.M.; Rubingh, 1983).

Use of the RST typically requires that the individual surfactant critical micelle concentrations (cmc's) be known. In addition use of the RST for a binary surfactant mixture requires input of an interaction parameter (the β_{RST} parameter), which reflects the interaction between the two surfactants types in the micelle (Goldsipe & Blankschtein, 2005).

The effect of temperature changes on the cmc of surfactants in aqueous solution have been found to be quite complex. It has been shown, for example, that the cmc of most ionic surfactants passes through a minimum (Cook, Fordyce & Trebbi, 1963) as the temperature is varied from~ 0 through 60-70°C. Non-ionic and zwitter ionic materials are not quite so predictable, although it has been found that some non-ionic reach a cmc minimum (Goddard, Hoeve & Benson, 1957) around 50°C.

Materials:

Purified and redistilled (Vogel,1994) acetone (BDH) was used for calibrating the dilatometer, viscometer, while a decinormal solution potassium chloride (MERCK, India) was used for the calibration of conductivity cell.

The surfactants Sodium Deoxycholate, (TOKYO KASEL, KOGYO CO. Ltd; Japan) as supplied was 95% pure and hence it has been recrystallised before used and N-Cetyl-N,N,N-trimethyl ammonium bromide (AR Grade, India) as supplied was 99% pure and used without Recrystallisation. $KMnO_4$ (MERCK, India) and NaOH (Qualigens Fine Chemicals; Mumbai, India) was used for the distillation of water. Purity of triple distilled water was checked by measuring its specific conductance which was found to 0.1×10^{-6} Scm^{-1} at 30°c.

2. Methods:

Purification of Acetone (Vogel, 1994): The acetone was refluxed with successive small quantities of potassium permanganate, until the violet colour persist. It was then dried with anhydrous calcium chloride, filtered from the desiccant and fractionated, b. p. 56-57°C. Precautions were taken to avoid the adsorption of moisture.

Preparation of triple distilled water: The supplied water was mixed with potassium permanganate into distillation plant which has a provision of distilling water three times. The distillation plant consists of three similar round bottom flask fitted in series with condensers and receives Permanganate water was distilled first and collected in the middle flask of the plant and again distilled and collected in the third flask which finally distilled and was collected for use.

2.1 Recrystallisation of Sodium Deoxycholate (Vogel, 1994):

Sodium Deoxycholate, (TOKYO KASEI, KOGYO CO. Ltd. Japan) was dissolved in ethanol and the solution was heated with activated charcoal and filtered hot. It was recrystallised by adding acetone to the concentrated filtrate. The white crystals obtained were vacuum dried.

2.2 Temperature and Concentration Range of Measurements:

The temperature range of measurements was from 25°C to 50°C with an interval of 5^0C. The concentration range of measurements for NaDC was 0.3 X 10^{-3} to 5.0 X 10^{-3} mol dm^{-3} and for CTAB was 0.5 X 10^{-3} to 2.5 X 10^{-3} mol dm^3 But in the case of the mixtures of surfactants the measurement range was in mole fraction and it was 0.1 to 0.9.

2.3 Temperature Control:

A thermostated water bath was used to maintain uniform temperature throughout the measurements. The bath consisted of a Remi stirrer (model no.RQD-1228) (220/230V), a check and a contact thermometer. The check thermometer was NBS calibrated to study the change in temperature ± 0.1 K, which was maintained with the help of relay (Jumo-Type - GKU 1OK, 220V~8A). A contact thermometer and an immersion rod (AC/DC, 230V, l000 watt) connected through a dimerstat to the power supply. The dilatometer, conductivity cell and viscometer were immersed in the water bath and the measurements were made after maintaining the thermal stability for half an hour.

2.4 Calibration of Dilatometer (Moynihan, 1966; Islam, Islam & Ahmad, 1979; Islam, Islam, Waris & Ismail, 1976) :

Dilatometer (PISCO Brand) 1s a flat bottomed flask of 8.2 cm^3 capacity fitted with a graduated stem of 7.0 cm length and 2.0 mm diameter. Each mark on the stem is divided into 0.01 ml. It was calibrated with triply distilled water of known density. It was washed thoroughly with chromic acid and triply distilled water and then dried in an oven. After completely dried, it was weighed on a digital balance (Adair-ADN-200W) and then filled with triply distilled water and weighed again. The dilatometer was then immersed in a thermostated water bath maintained at the required temperature of ± 0.1 K thermal stability for half an hour. The temperature was increased by means of contact thermometer so that the level of water in the stem of dilatometer gets increased. The temperature corresponding to each mark of the stem was recorded.

The densities of triply distilled water at these temperatures were obtained by means of an empirical equation of the type $\rho = a - bT$ ……. (1)

Where ρ is the density of water, 'a' and 'b' are the constants and T is the temperature corresponding to each mark on the stem of dilatometer. It was also

found that reported densities of water were linear in the temperature range of our interest (25°C-50°C).

According the temperature dependence of density data of water was least-squares fitted to equation (1) and the best fit values of 'a' and 'b' were computed. Using the values of 'a' and 'b' the densities of these temperatures corresponding to the marks in the stem of the dilatometer were computed. The ratio of mass of water to the above calculated density at the respective temperatures gave the volume of the dilatometer at the corresponding mark on the stem.

Then the clean, dried, empty and weighed dilatometer was filled with purified and redistilled acetone and after weighing again, immersed in the thermostated water bath maintained at the required temperature. The temperature corresponding to the volume of each mark of the stem was recorded in a manner similar to that applied in the case of distilled water. Then from the temperature-volume data, the densities of acetone at these corresponding temperatures were calculated. The whole procedure was repeated with different amounts of water and acetone. The densities of purified acetone was measured by repeating the above mentioned procedure and compared with those of the reported values (Vogel, 1994). The reproducibility was found to be within ± 0.00026 gm cm^{-3}.

2.5 Calibration of Viscometer (Islam, Islam & Ahmad, 1979; Islam, Islam, Waris & Ismail, 1976; Canon, 1960):

Canon Ubbelohde viscometer (Master suspended Level, BS/VSL/MV) consist of three parallel arms, a receiving arm, a measuring one and auxiliary one forming 'W' type arrangement. The receiving arm forms a 'U' shaped arrangement with the measuring arm through a bulb 'D'. The auxiliary arm is sealed to measuring arm has two bulbs 'A' and 'B' in the upper portion. The bulb 'B' is slightly below the bulb 'A'. Two fiducial marks 'a' and 'b' on these bulbs were used for recording the time of fall of test liquids.

In between bulbs 'B' and 'C' there is a capillary of 6.8 m length. It has been designed to align the center of gravity of all the three bulbs vertically to reduce the acceleration due to gravity and minimize the experimental error.

Special features of the suspended level of the viscometer are that the capillary effects of the various liquids surfaces were neutralized by each other so that the surface tension correction for the apparatus was negligible and the transport movement was carried out freely under the weight of the total volume of the test liquid.

The viscometer was cleaned with chromic acid, washed, dried and filled with sufficient amount of triply distilled water to avoid nay air bubble being introduced into the

capillary arm. The viscometer was then suspended in the thermostated water bath for about half an hour before recording the time of fall in order to ensure thermal stability ± 0.1 K at the required temperature. Two guard's tubes containing anhydrous calcium chloride were attached to the auxiliary and receiving arms of the viscometer in order to avoid the absorption of moisture.

Measurement of Viscosity: The calibrated viscometer was cleaned, dried and filled with the required amount of each concentration of the surfactant solutions and clamped in water bath maintained at the required temperature. The viscometer containing the sample was allowed to stand for half an hour in the thermostated water bath in order to avoid thermal fluctuations in the viscometer. The measurements were made at 25-50°C after an interval of 5^0C, the viscosity was calculated by means of equation.

Results and Discussion

Density

The experimental values of density ρ (kg m^{-3}) for aqueous solutions of Sodium Deoxycholate (NaDC) and N-Cetyl N,N,N-trimethyl (CTAB) observed as functions of concentration and temperature and presented in Table1. The experimental values of density for aqueous solutions of mixtures of (NaDC) and N-Cetyl N,N,N-trimethyl (CTAB) are also observed as functions of mole-fraction and temperature and presented in

Table1&Table2.

Table- 1: Density ρ x 10^3 (Kg m^{-3}) for Aqueous Solutions of NaDC as Functions of Concentration and Temperature

T(K) c x10^3(mol dm-3)	298.15	303.15	308.15	313.15	318.15	323.15
0.3	0.990	0.988	0.987	0.986	0.985	0.930
0.5	0.991	0.990	0.989	0.988	0.987	0.984
1.0	0.992	0.991	0.990	0.989	0.988	0.985
1.5	0.993	0.992	0.990	0.990	0.989	0.986
2.0	0.994	0.993	0.991	0.990	0.990	0.980
2.5	0.995	0.994	0.992	0.991	0.991	0.990
3.0	0.996	0.994	0.993	0.992	0.991	0.988
3.5	0.997	0.995	0.993	0.993	0.992	0.988
4.0	0.997	0.996	0.994	0.993	0.993	0.990
4.5	0.998	0.997	0.995	0.994	0.993	0.991
5.0	0.999	0.998	0.995	0.995	0.994	0.992

Table-2: Density ρ x 10^3 (Kg m^{-3}) for Aqueous Solutions of CTAB as Functions of Concentration and Temperature

T(K) C X 10^3 (mol dm^{-3})	298.15	303.15	308.15	313.15	318.15	323.15
0.50	0.989	0.988	0.987	0.986	0.985	0.984
0.60	0.990	0.989	0.988	0.987	0.986	0.985
0.75	0.991	0.990	0.989	0.988	0.986	0.985
0.90	0.992	0.991	0.990	0.989	0.987	0.986
1.00	0.993	0.992	0.990	0.984	0.988	0.987
1.25	0.994	0.993	0.991	0.990	0.989	0.987
1.50	0.995	0.994	0.992	0.99	0.990	0.988
1.75	0.996	0.995	0.993	0.992	0.991	0.989
2.00	0.997	0.996	0.994	0.993	0.992	0.989
2.25	0.998	0.997	0.995	0.994	0.993	0.990
2.50	0.999	0.997	0.996	0.995	0.993	0.991

The temperature dependence of density data is expressed in the form of an empirical equation, $\rho = a - bT$ . . . (2)

Where 'ρ' is the density of the solution, 'a' and 'b' are constants and 'T' is the absolute temperature. The temperature dependence data of observed density for all the concentrations of NaDC, CTAB and their mixtures are least-square fitted to equation (2) and the computed values of the density parameters 'a' and 'b' along with the values of standard deviation 'σ' are, respectively given in Table 3, Table 4 and Table 5.

Table-**3:** Least Squares-Fit Parameters of Density Equation for Aqueous Solutions of NaDC as a Function of Concentrations

C X 10^3 (mol dm^{-3})	a	-bX 10^3	σ X 10^3
0.3	1.094	0.34	0.07
0.5	1.095	0.34	0.09
1.0	1.096	0.35	0.09
1.5	1.097	0.35	0.12
2.0	1.099	0.35	0.09
2.5	1.101	0.36	0.06
3.0	1.103	0.36	0.07
3.5	1.101	0.35	0.08
4.0	1.099	0.35	0.06
4.5	1.099	0.35	0.05
5.0	1.098	0.34	0.05

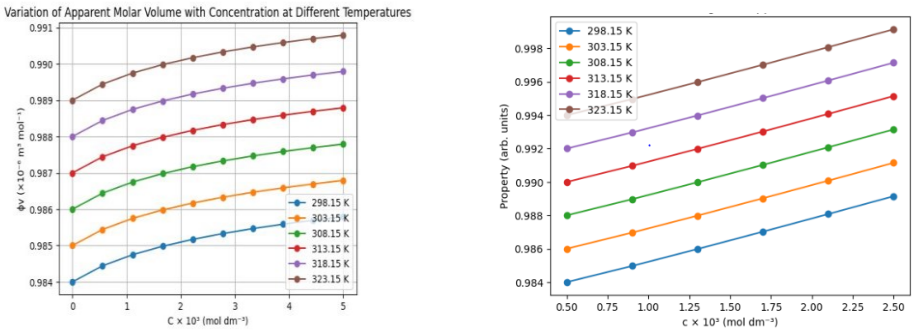
Table- 4: Least Squares-Fit Parameters of Density Equation for Aqueous

C X 10^3 (mol dm^{-3})	a	-b X 10^3	σ X 10^3
0.50	1.049	0.20	-
0.60	1.049	0.20	0.04
0.75	1.048	0.19	0.06
0.90	1.046	0.19	0.08
1.00	1.047	0.19	0.10
1.25	1.045	0.18	0.09
1.50	1.044	0.17	0.11
1.75	1.042	0.17	0.13
2.00	1.041	0.16	0.10
2.25	1.041	0.16	0.09
2.50	1.040	0.15	0.06

Table- 5: Least Squares-Fit Parameters of Density Equation for Aqueous Solutions of Mixtures of NaDC and CTAB as a Function of Mole-fractions.

α_{CTAB}	a	-b X 10^3	σ X 10^3
0.1	**1.025**	**0.09**	**0.06**
0.2	**1.026**	**0.10**	**0.07**
0.3	**1.026**	**0.10**	**0.07**
0.4	**1.027**	**0.10**	**0.10**
0.5	**1.027**	**0.10**	**0.06**
0.6	**1.028**	**0.10**	**0.08**
0.7	**1.028**	**0.10**	**0.08**
0.8	**1.029**	**0.10**	**0.08**
0.9	**1.029**	**0.10**	**0.08**

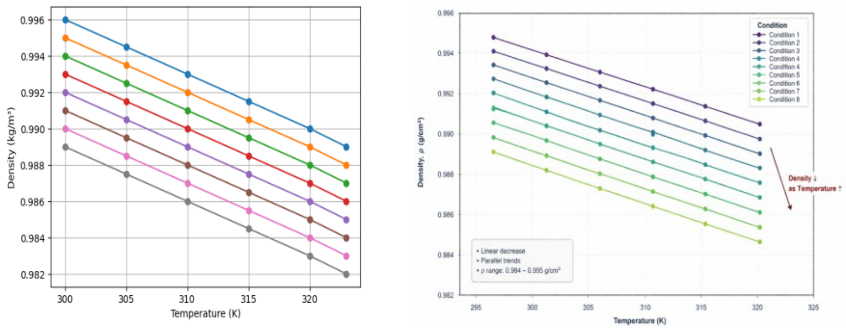
The density values of aqueous solutions of the surfactants and their mixtures are found to increase with the increase in concentration at each temperature and decrease with the increase in temperature at each concentration in a regular manner. The plots of density values of the surfactants NaDC, CTAB and their mixtures against concentrations at various lcn1peraturcs arc shown in Figure1 and Figure2.



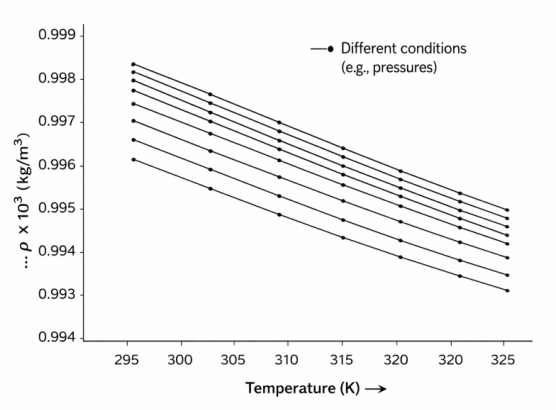
(a) (b)

Fig1:-Plots of Density versus Concentration for Aqueous Solutions of (a) NaDC at Various Temperatures (b) CTAB at Various Temperatures

These plots show that there is an increase in the density values upto certain concentration after which there is a sudden change in the slope of density versus concentration plot indicating the existence of micelles. Each plot shows two lines segments with a sharp break point corresponding to cmc at that particular temperature. A linear decrease in density value with increase in temperature is observed (Figure3, Figure 4 and Figure 5).



(a) (b)



(c)

Fig3:-Plots of Density versus Temperature for Aqueous Solutions of (a) NaDC at Various Temperatures (b) CTAB at Various Temperatures (c) NaDC and CTAB at Various Temperatures

The decrease in density is caused by an increase in volume of solution on increasing the temperature since the mass remains constant, while the magnitude of mass to volume ratio decreases. The experimental values of density were used in the determination of viscosity values and it is also being used to evaluate the mole fraction of water in solution.

3. Conclusion

In the light of the observed density, viscosity and electrical conductance of aqueous solutions of Sodium Deoxycholate, N-Cetyl N,N,N-trimethyl ammonium bromide and their mixtures as functions of concentration and temperature, the reduced η_{red} and intrinsic $[\eta_m]$ viscosities and the cmc values were determined as a function of temperature. From the values of standard Gibbs energy change ΔG_m^0, standard enthalpy change ΔH_m^0 and standard entropy change ΔS_m^0, it may be concluded that the micellization process of aqueous solutions of Sodium Deoxycholate, N-Cetyl, N,N,N-trimethyl ammonium bromide and their mixtures is spontaneous, as it is evident from the values of ΔG_m^0. Further the temperature dependence of viscosity parameters favours spherical geometry for those individual surfactants and their mixtures.

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Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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Facilitating Gender Justice in Education: an Analytical Study on Teachers' Role in Women's Empowerment and Social Change in Assam

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Abstract

This review paper explores the role of teachers' beliefs and pedagogical practices in shaping women's empowerment within Assam's educational landscape. Women's empowerment through education is increasingly recognized as a cornerstone for achieving social equity and sustainable development. However, in Assam, persistent gender disparities, socio-cultural constraints, and unequal learning opportunities continue to hinder women's full participation in education. Drawing upon national and regional literature, the paper highlights how teachers' attitudes, expectations, and gender-sensitive pedagogical approaches critically influence female students' motivation, academic achievement, and self-confidence. Studies reveal that while many educators in Assam display supportive attitudes towards women's empowerment, subtle biases and traditional classroom practices still reinforce gender hierarchies. By synthesizing evidence from existing research, the paper underlines the urgent need for teacher training, curriculum reform, and policy interventions that promote equitable classroom practices. Ultimately, the study argues that teachers in Assam hold a decisive role not only as transmitters of knowledge but also as agents of social change, making their beliefs and practices pivotal in shaping the trajectory of women's empowerment in the region.

Keywords: Teacher beliefs, Pedagogical practices, Women's empowerment, Gender equality in education, Educational landscape, Gender-sensitive pedagogy, Teacher attitudes

1. Introduction

Between 2000 and 2025, Assam has witnessed a gradual but perceptible shift in its educational landscape, revealing both progress and persistent disparities impacting women's empowerment. As of 2024, the state's overall literacy rate stood at approximately 72.19 percent, with male literacy at 77.85 percent and female literacy significantly lower at 66.27 percent, underscoring enduring gender gaps in access to education (Wikipedia, 2025). Importantly, teachers through their attitudes, classroom conduct, and representation play a pivotal role in shaping gender norms and empowering female students. In rural Assam, a recent study of in-service teachers found pervasive gender stereotyping in classroom activities, illustrating how inherent biases can influence girls' engagement and self-belief (Das, 2024). Simultaneously, women's literary movements such as the *Sadou Asom Lekhika Samaroh Samiti*, founded in 1974, have fostered cultural avenues for creative expression, contributing to broader empowerment narratives within teaching and educational discourses **(**Sadou Asom Lekhika Samaroh Samiti, 2025). By exploring these intersections of literacy, educator attitudes, and literary-cultural frameworks, this seminar aims to illuminate how modern education in Assam shapes and is shaped by women's empowerment.

1.1 Review of Related Literature

Research over the past two decades has consistently shown that teacher attitudes and beliefs play a critical role in shaping gender outcomes in education. Rakshit and Sahoo (2023) analysed large-scale Indian learning outcome data and found that teacher bias significantly reduces girls' cognitive and non-cognitive gains, contributing to persistent gender gaps. In Assam's context, the National Council of Educational Research and Training (NCERT, 2017) conducted a textbook content analysis and reported that visuals and narratives in Assamese textbooks often reinforce stereotypical gender roles, underlining the need for curriculum reform and teacher sensitization. Similarly, (Das, 2024) examined rural Assam schools and revealed that teacher encouragement is often gendered, particularly in science subjects, restricting girls' aspirations.

Studies in early childhood education also highlight the formative influence of teacher perceptions. Sarma *et al.* (2024), in a qualitative study in Jorhat district, found that preschool teachers hold implicit gendered assumptions that shape early learning experiences, calling for targeted pre-service and in-service training. (Saikia, 2023), in a Kamrup district college teacher survey, reported that while many educators express theoretical support for gender equality, these beliefs are not consistently translated into classroom practice. UNESCO's (2006) policy review confirmed that the presence of women teachers increases girls'

enrolment, yet stressed that attitudes and pedagogical approaches determine the extent of empowerment.

Broader state-level studies, such as Abdul (2019), show persistent gender gaps in literacy and enrolment in Assam, with variation across districts linked to institutional and teacher-related factors. Program evaluations of Mahila Samakhya initiatives (Sharma, 2024) emphasise that community-based education works best when teachers actively foster empowerment. (Mandal, 2018) similarly noted that textbooks perpetuate occupational and social role stereotypes, which can undermine gender equity efforts unless countered by teachers. The National Education Policy 2020 (Government of India, 2020) identifies teacher education reforms as essential for delivering gender-responsive classrooms, an approach particularly relevant for Assam's diverse socio-cultural settings.

Data from DISE and ASER reports (2010–2020) reveal significant district-level disparities in girls' retention and subject choice, often reflecting the local teacher workforce's attitudes. Research with B.Ed. trainees (2018–2024) indicates that while female trainees tend to express stronger egalitarian views, stereotypical career expectations persist, suggesting the need for curriculum-based gender sensitisation. Ghosh (2016) reviewed national literature and found recurring evidence that teacher beliefs and classroom interactions are central to the reproduction of gender inequality in schools. NCERT and other content analyses (2017–2021) confirm the under-representation of women in professional roles in textbooks, with teachers' capacity for critical pedagogy emerging as a crucial countermeasure.

In the early years, teacher expectations have been linked to long-term educational trajectories, as shown in both Assam-specific and broader Indian studies (Sarma *et al.,* 2024). Program evaluations of girls' retention initiatives in tea-garden and rural areas (2010–2025) highlight the success of interventions that integrate gender training for teachers. Similarly, STEM participation research demonstrates that lower levels of encouragement for girls in science subjects correlate with reduced uptake in higher secondary streams. Community-level empowerment studies in Assam (2015–2024) show that while education increases women's agency, entrenched social norms and school-level factors, including teacher attitudes, can moderate these gains. Reviews of teacher professional development (2005–2023) stress that generic training rarely shifts gender attitudes; instead, practice-embedded and gender-specific mentoring has greater impact. Finally, open and distance learning (ODL) programs in Assam (RSIS International, 2025) reveal expanded access for women but caution that without gender-responsive facilitation, such platforms may fall short of genuine empowerment.

1.2 Significance of the Study

Over the past two decades, Assam has witnessed substantial socio-economic and educational transformations, with modern education emerging as a key driver for women's empowerment. However, the extent to which this potential is realized largely depends on the attitudes and perceptions of teachers, who act as the primary facilitators of learning. In the context of Assam where traditional norms, cultural practices, and regional disparities often shape gender roles, teachers' beliefs and pedagogical approaches can either reinforce gender biases or foster equality.

From 2000 to 2025, government initiatives such as *Beti Bachao Beti Padhao*, expansion of girls' scholarships, and the implementation of the National Education Policy (2020) have aimed to promote gender-inclusive education. Despite these efforts, persistent issues such as unequal participation in various fields, lower female representation in higher education leadership, and socio-cultural resistance to women's full participation highlight the need to examine the subtle but powerful influence of teachers' attitudes on educational outcomes for girls and women.

This study is significant as it bridges the gap between policy intent and classroom reality in Assam. By systematically analyzing literature spanning 25 years, it reveals how teacher attitudes shaped by cultural values, institutional constraints, and evolving educational frameworks impact women's empowerment through education. The findings will inform teacher training programmes, curriculum design, and policy reforms, ensuring that educational spaces in Assam are more equitable and inclusive. Ultimately, the study contributes to strengthening the role of modern education as a transformative tool for advancing gender equality and fostering women's active participation in socio-economic and cultural life.

From this point of view, it is crucial to examine the extent to which individuals are exposed to the empowerment process and the degree to which they have actually been empowered. Such an inquiry requires a systematic assessment of the various indicators of empowerment present in Assam. In line with this objective, the present study has been designed to explore and analyze the empowerment of women through education.

1.3 Objectives of the Present Study

The aim of this study is to investigate and analyse the specific objectives and goals that are to be achieved through the research conducted.

1. To Examine Teachers' Attitudes towards Women's Empowerment in Modern Education in Assam.

2. To analyze the impact of Teachers' attitudes on Women Students' Academic Performance and Motivation.
3. To examine the relationship between Teachers' attitudes and Women Empowerment in educational settings.
4. To Identify Socio-Cultural and Institutional Barriers and Strategies for promoting Positive Teachers' Attitudes and Women Empowerment in Modern Education in Assam.

1.4 Research Methodology

This Seminar paper adopts a descriptive and analytical approach, conducting a comprehensive literature review on the topics of Modern Education, Teacher Attitudes, Assam, NEP 2020, and Women Empowerment.

2. Data Analysis

The process of examining and interpreting data in order to uncover meaningful patterns, relationships, and insights. The collection of literature presented below elucidates the importance of the research problem from several vantage points. The review has been organised under various thematic categories, including:

3. Result and Discussion

Objective 1: to Examine Teachers' Attitudes towards Women's Empowerment in Education in Assam

Teachers' attitudes play a decisive role in shaping women's empowerment through education. (Sen, 1999) described empowerment as expanding women's capabilities and choices, which schools can nurture only if teachers provide equitable opportunities. (Rosenthal and Jacobson, 1968) showed that teachers' expectations influence students' motivation, while Stromquist (2015) emphasized that gender-sensitive pedagogy is vital for empowerment.

In India, Nambissan (1999) highlighted that subtle teacher biases often reinforce traditional gender roles, and Kingdon (2007) argued that positive teacher attitudes encourage higher enrolment and retention of girls. Extending this to Assam, Das (2016) found that teachers who mentor and motivate girls significantly improve their confidence and decision-making. Similarly, Talukdar (2017) noted that many rural Assamese girls pursued higher studies only when teachers inspired them to aspire beyond secondary education.

Baruah (2020) further showed that supportive teachers enabled girls to take part in debates, cultural activities, and student leadership, enhancing empowerment. However,

challenges remain. Gogoi (2015) observed that Assamese classrooms often lack gender sensitivity, with boys given more visibility in academic tasks. Bhuyan (2019) argued that teacher training rarely addresses gender equity, limiting teachers' ability to promote empowerment. Hazarika (2018) added that without community support, teacher efforts sometimes fail to overcome entrenched patriarchal barriers.

On a positive note, Nath (2021) stressed that female teachers in rural Assam serve as role models, inspiring girls to pursue education and careers. Gogoi and Dutta (2022) highlighted that government schemes such as scholarships and bicycles succeed best when teachers actively encourage girls to benefit from them.

Overall, literature suggests that in Assam, teachers' attitudes are central to whether education merely imparts literacy or becomes a genuine force of empowerment. Encouragement, equitable practices, and mentorship by teachers can transform women students into confident, capable individuals who challenge traditional gender norms.

1. Role of Women Teachers as Catalysts

- **Primary education impact**: **Devi, B.(2012)**. Mentioned that Women teachers play a vital role in the all round development of a child. In primary schools of Assam, there is least number of women teachers. They face various problems. To increase the number of women teachers in primary schools, importance should be given to overcome the problems of women teachers. It highlights their essential role in early childhood learning, documents challenges they face including low representation and proposes measures to overcome these barriers to enhance female participation and improve educational outcomes in the region.
- Lalrinhlui, & Sailo, V. (2023). This study was conducted to find out the attitude of secondary school teachers of Aizawl city towards women empowerment. The sample of the study comprised of 150 secondary school teachers and the findings of the study revealed that majority of the teachers i.e., 84.65% have positive attitude towards women empowerment. The findings also showed that educational qualifications and marital status did not have any role in determining attitude towards women empowerment of secondary school teachers. The type of school management, i.e., government, private and deficit did not have any role in determining the attitude of secondary school teachers towards women empowerment
- **Kothari Commission's insight**: Highlighting that "the destiny of the country is being shaped in the classroom and teachers hold the key position" underscores the influence of

educator attitudes on students' empowerment trajectories. Female teachers not only provide comfort and representation, they shape foundational learning experiences and aspirations for girls.

2. Persistence of Gender Gaps despite Progress

a) Empowerment still lagging: Multiple studies show that in Assam:

- Women remain underrepresented in government roles and political participation.
- Female enrollment rates remain below 50%, despite educational schemes like the Mid-Day Meal.
- There's significant district-level variation; literacy correlates with female workforce participation, but gender disparities endure.

From this Teachers' attitudes are a critical factor in bridging these gaps. Positive attitudes can help sustain girls' enrollment and empowerment; negative ones may undermine even well-intentioned policies.

Teachers' attitudes are crucial for modern education's role in women's empowerment, with research showing that supportive, inclusive attitudes from both male and female educators foster environments where girls feel empowered to pursue their goals and challenge norms. Positive teacher attitudes, encompassing empathy, inclusivity, and a collaborative approach, are key to creating inclusive classrooms and inspiring young girls to become agents of change.

Objectives 2: Analyze the Impact of Teachers' Attitudes on Women Students' Academic Performance and Motivation (Assam Context)

In Assam, Aditi Das (2024) highlights how gender stereotyping by teachers in rural classrooms can limit girls' engagement and academic performance, while Binita Devi (2012) underscores that the presence of female teachers fosters trust and motivates young girls demonstrating the dual impact of teacher identity and attitudes.

Scholars have long argued that teachers' attitudes significantly affect students' motivation and learning outcomes. Rosenthal and Jacobson (1968) introduced the concept of the "Pygmalion effect," where teachers' expectations influence students' achievement. In the Assam context, Bordoloi (2012) highlights that female students' success in secondary schools is closely linked with teacher encouragement and support. Similarly, Gogoi (2015) found that in many Assamese rural schools, the lack of gender-sensitive teaching practices reduces girls' classroom participation and motivation. A district-level study in Dibrugarh by Saikia (2018) observed that academic achievement motivation among Class X students was directly

correlated with teachers' supportive attitudes, showing that female students performed better when they perceived teachers as approachable and encouraging. These findings suggest that teacher attitudes act as a catalyst for improving not only academic performance but also the confidence and aspiration of women students in Assam.

Objective 3: to examine the relationship between Teachers'Attitudes and Women Empowerment in Educational Settings

In Assam, the relationship between teachers' attitudes and women's empowerment in education is a significant area of study because teachers act as key change agents in shaping gender perceptions and guiding students' aspirations. Women's empowerment in education goes beyond enrollment; it depends on how teachers encourage, mentor, and provide equal opportunities to girls in classrooms. As Baruah (2013) notes, patriarchal values and cultural restrictions in Assam often limit girls' educational progress, but supportive teachers can challenge such barriers by motivating female students to continue higher studies. Similarly, Devi (2015) emphasizes that teacher' positive attitudes help build self-confidence among girls, particularly in rural and tribal areas where socio-cultural constraints are more pronounced.

Sharma and Das (2017) argue that empowerment involves self-reliance, participation, and decision-making abilities, which teachers can promote by creating inclusive and gender-sensitive learning environments. In Assam, where dropout rates among adolescent girls remain a concern (NSSO, 2019), teacher encouragement is directly linked to reducing early marriage and school withdrawal. Phukan (2020) highlights that when teachers promote awareness on issues such as menstrual health, safety, and equal classroom participation; they contribute significantly to women's empowerment.

Further, Borah and Gogoi (2021) observe that gender equity training for teachers in Assam enhances their sensitivity and translates into improved student outcomes, including higher aspirations and active participation in leadership roles. Thus, the relationship between teachers' attitudes and women's empowerment is reinforcing: empowered and gender-aware teachers nurture empowered learners. In the context of Assam, examining this relationship becomes crucial to understanding how teacher behavior, classroom practices, and institutional support can transform women's educational opportunities and contribute to broader goals of gender justice and socio-economic development.

Dutta (2019) reveals that girls in rural Assam have significantly lower awareness of empowerment compared to their urban peers, suggesting that teachers' attitudes in rural

schools may be a key missing link. Complementing this, Saikia (2020) shows that among tea-tribe communities, educational access for women is impeded by socio-economic constraints, which teachers must actively counteract. Moreover, Nayak & Mahanta's broader socio-economic analysis of Assam (2013/2025) indicates that women's limited autonomy and participation reflect systemic issues that teacher-student dynamics alone cannot resolve." Teachers not only transmit knowledge but also act as agents of social change. Sen (1999) in his capability approach emphasized that empowerment through education depends on the environment created by educators. In Assam, Das (2016) pointed out that teachers who maintain positive gender attitudes help female students develop decision-making abilities, self-confidence, and leadership qualities within school settings. Talukdar (2017) further demonstrated that in rural Assamese schools, women students' continuation to higher education was strongly influenced by the motivational role of teachers, who encouraged them to pursue studies despite socio-economic barriers. Baruah (2020) examined secondary schools in Upper Assam and argued that when teachers display gender-equitable attitudes, girls are more likely to challenge stereotypes and actively participate in school councils, debates, and leadership roles, which directly links to empowerment. Thus, the relationship between teacher attitudes and empowerment in Assam lies in the way educator's foster agency, aspiration, and equal opportunity for women learners.

Objective4 : To Identify Socio-Cultural and Institutional Barriers and Strategies for Promoting Positive Teachers' Attitudes and Women's Empowerment in Modern Education in Assam

Women's empowerment in education is shaped not only by teacher attitudes but also by the socio-cultural and institutional contexts in which schools function. Stromquist (2015) argued that patriarchal norms often influence teachers' behaviors, reproducing gender hierarchies within classrooms. In India, Nambissan (1999) showed that family expectations, early marriage, and domestic responsibilities restrict girls' education, indirectly shaping teachers' perceptions of female students.

In Assam, several studies have highlighted socio-cultural barriers. Gogoi, L (2015) observed that traditional gender norms in rural Assam often discourage girls from pursuing higher studies, which affects teacher motivation to invest in their future. Hazarika, N. (2018) added that community resistance and parental skepticism limit the effectiveness of even supportive teachers. Nath, S. (2021) emphasized that the lack of female role models in certain

regions perpetuates stereotypes, reducing both teachers' and students' belief in women's empowerment.

Institutional barriers also remain significant. Bhuyan, T. (2019) argued that teacher training programs in Assam rarely incorporate gender-sensitivity modules, leaving many teachers unaware of how to encourage female empowerment. Das, R. (2016) noted that resource constraints, poor infrastructure, and overcrowded classrooms further prevent teachers from engaging equally with boys and girls. Talukdar,P. (2017) also pointed out that weak policy implementation means government schemes for girls' education often fail without active teacher involvement.

Strategies suggested in literature include gender-sensitive teacher training (Unterhalter, 2012), mentorship programs led by female educators (Nath, S. 2021), and linking government schemes with teacher encouragement (Gogoi & Dutta, 2022). Stromquist (2015) emphasized integrating gender equity into pedagogy, while Baruah (2020) stressed extracurricular participation as a tool for empowerment.

Thus, in context of Assam addressing socio-cultural prejudices, strengthening teacher preparation, and ensuring institutional support are essential for transforming teachers' attitudes into agents of women's empowerment in modern education.

4. Findings

1. **Teachers' attitudes are pivotal to women's empowerment:**
   Literature across Assam and broader India consistently shows that teachers' perceptions, expectations, and behaviors significantly shape girls' access, retention, and academic performance. Supportive teacher attitudes boost self-confidence, aspirations, and leadership opportunities for female students, while negative or stereotypical attitudes limit participation and motivation.
2. **Persistent gender bias in classroom practices:**
   Studies (Das, 2024; Gogoi, 2015) reveal that many Assamese classrooms still reflect gender stereotyping, with boys often prioritized in science subjects, leadership roles, or classroom interactions. These practices contribute to enduring gender gaps in learning outcomes and career aspirations.
3. **Female teachers as role models:**
   Research (Nath, 2021; Devi, 2012) highlights that female teachers inspire girls to pursue education and overcome social barriers. However, their representation in rural

and primary schools remains low, limiting their potential as catalysts of empowerment.

4. **Socio-cultural and institutional barriers:**
   Patriarchal norms, early marriage, and household responsibilities continue to discourage girls from pursuing education. At the institutional level, inadequate gender training for teachers, poor infrastructure, and weak policy implementation hinder empowerment efforts.
5. **Need for gender-responsive teacher training:**
   Many studies recommend targeted pre-service and in-service training to foster gender awareness among teachers. Practice-embedded approaches, mentorship programs, and linking government schemes with teacher encouragement emerge as effective strategies.

5. Conclusion

The review establishes that in Assam, teachers' attitudes form the crucial link between modern education and women's empowerment. While state-level policies and literacy growth have created opportunities, the classroom remains the decisive space where empowerment is either nurtured or constrained. Teachers who adopt inclusive, empathetic, and gender-sensitive approaches not only improve girls' academic outcomes but also cultivate their agency, self-confidence, and leadership skills. Conversely, gender bias in pedagogy perpetuates social inequities and weakens empowerment efforts.

The study concludes that achieving genuine women's empowerment in Assam requires a **multi-pronged approach**: (i) strengthening teacher training with gender equity modules, (ii) increasing the presence of female teachers, especially in rural schools, (iii) integrating community participation to counter socio-cultural resistance, and (iv) aligning policies such as NEP 2020 and Samagra Shiksha with classroom-level teacher practices.

Ultimately, teachers are not merely transmitters of knowledge but agents of social change. By reshaping attitudes and practices, educators can transform modern education in Assam into a powerful vehicle for achieving gender justice and empowering women to actively participate in socio-economic and cultural life.

Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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A Study on Educational Attainment and Its Distribution

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Abstract

Background: Education is the process of the acquisition of knowledge, or facilitating learning and skills values belief include narrative discussion training, teaching and directed research. It is imported for living a better life. Education is the strength to an education and person need to. This study was conducted to study the status of education level under Lakhimpur district, special references of Batamari village. **Objectives:** the objectives of the study were to see the education level of Batamari village and the economic condition of the family of Batamari village of Lakhimpur district. **Methods:** The present study on status of education level of Lakhimpur district, we have decided to use systematic sampling, more clearly we use circular systematic sampling to collection of data. Chi-square tests were used to test the education level and economic condition of the households. Education is a crucial determinant of socio-economic development. This study examines the distribution of educational qualifications among respondents using descriptive statistics and the Chi-square goodness-of-fit test. Data collected from 100 respondents reveal that educational attainment is unevenly distributed, with a concentration at the secondary level and a sharp decline in higher education. The Chi-square test confirms that the observed distribution significantly differs from a uniform distribution ($\chi^2 = 30.75$, df = 6, $p < .05$). The findings highlight the need for policies to improve higher education accessibility and reduce illiteracy.

Keywords: *Education, Chi-square test, Educational Distribution, Socio-economic Development*

1. Introduction

Education is the process of acquiring knowledge, skills, values, beliefs, and habits through various methods such as teaching, training, storytelling, discussion, and directed research (Baraza & Silvance, 2019; UNESCO, 2015). It typically occurs under the guidance of educators; however, individuals may also engage in self-learning. Education can take place in both formal and informal settings, and any experience that influences the way a person thinks, feels, or acts may be considered educational (McKinney, 2018).Formally, education is structured into stages such as preschool or kindergarten, primary education, secondary education, and higher education, including college, university, or apprenticeship (Srikanth, 2015).

1.1 Importance of Education

Education is one of the most essential aspects of human life and plays a vital role in personal and social development. It enables individuals to lead a better quality of life and contributes to social welfare (Bhoje, 2015; Todaro & Smith, 2020). Education enhances knowledge, critical thinking, and decision-making abilities, thereby helping individuals distinguish between right and wrong (Jakobson, 1986).

Furthermore, education is crucial for personal growth and professional development. It prepares individuals to participate effectively in organizations, institutions, and society at large. An educated person is more likely to become a responsible citizen and contribute positively to the economy and society (Sen, 1999).

In the modern world, education is considered a basic necessity after food, clothing, and shelter. It promotes awareness, values, and responsible behavior, helping to address issues such as corruption and social inequality (Tilak, 2002). Additionally, technological advancements have strengthened the role of education by facilitating communication and access to knowledge (Ministry of Education, 2020).

1.2 Education in Assam

Assam is one of the states in North-East India with a distinctive educational landscape. According to the Census of India (2011), the literacy rate of Assam was 73.18%, which is slightly below the national average. The state has established numerous educational institutions catering to the North-Eastern region (Government of Assam, 2018).

The formal education system includes elementary, secondary, and higher secondary levels, followed by higher education in colleges and universities. Several initiatives have been undertaken to promote universal elementary education (Ministry of Education, 2020).

Elementary education generally covers children aged 6–14 years, and the government provides free and compulsory education up to this age (Census of India, 2011). Assam has also developed several higher educational institutions that contribute to academic and professional development in the region.

1.3 The Study Area

The study is carried out at Batamari (No. 1 Batamari & No. 2 Batamari), Dhakuakhana, under Lakhimpur District in Assam. According to 2011 census of India 114095 people live in District covering a geographical area of 313.00 Sq.km. out of this 57791 are male and 56304 are female (Saikia *et al*., 2019).

Batamari is one of the Village of Dhakuakhana block, in Lakhimpur District of Assam. Male and Female literacy rate is average, but people are very active and always making efforts in knowing the works of government Officials (Saikia *et al*., 2019). There are so many problems that Batamari Village is water supply shortage, rationing of food grains issues unemployment etc. Health problem is rampant in this Village. People have to travel several kilometers to reach hospital for treatment of patients.

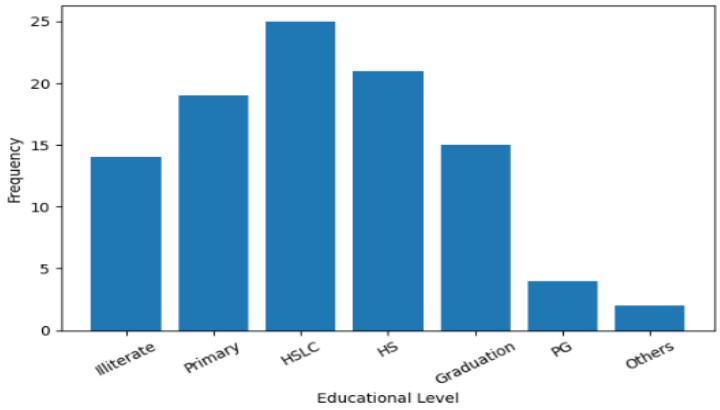

Fig1: Bar Diagram Showing Distribution of Educational Attainment among Respondents

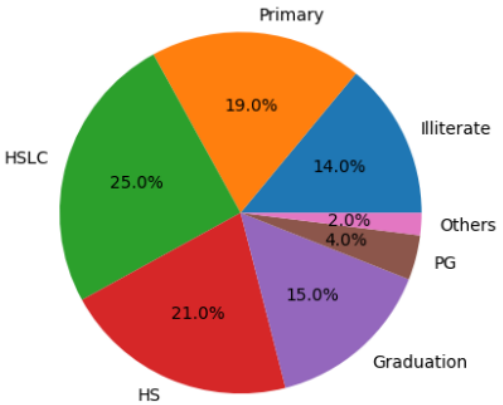

Fig2: Distribution of Educational Attainment among Respondents

1.4 Objective of the study

The objectives of the present study are:

i) To examine the distribution of educational qualifications.

ii) To test whether the distribution is statistically uniform.

iii) To identify disparities in higher education attainment

2. Material for the study

As my objective are given above, so I had to collect information regarding

- Age of the household head.
- Education level of the household head.
- Other family member education level.
- Economic condition of the family.

2.1 Methods

A sample is a part of universe. More specifically is a group of item selected from the population for the purpose of getting information about the characteristic of the items of the population. It is known that if the sampling is not done using a standard statistical procedure, then the statistical technique cannot be used to infer about the population.

2.2 Chi-Square Test for Goodness of Fit

A very powerful test for testing the significance of the discrepancy between theory and experiment was given by Prof. Karl Pearson in 1900 and is known as "chi-square test of goodness of fit".

If f_i (i= 1,2,3,,…,n) is a set of observed (experimental) frequencies and e_i (i=1,2,3,…,n) is the corresponding set of expected frequencies , then Karl Pearson's chi-square given by,

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{s} \left[\left| \frac{(f-e)^2}{N} \right|, \sum_{i=1}^{r} f = \sum_{j=1}^{s} e \right.$$

χ^2 = distribution with (n-1) d.f.

3. Analysis of Data

Analysis of data is the main part of any scientific investigation. After collecting the data, the data must be scrutinized, edited and tabulated and then a very careful statistical analysis is to be made and finally a report cooperating detailed statement of the different stages of the survey should be prepared. For computing purpose we have taken help of software like MS-Excel, SPSS describes scientific calculator (fx-82 MS).

For all inferences we fix $\alpha = 0.05$

Table1: Primary Survey

Characteristics		Frequency	Percentage (%)
Valid	illiterate	14	13.9
	Primary	19	18.8
	HSLC	25	24.8
	HS	21	20.8
	Graduation	15	14.9
	PG	4	4.0
	Others	2	2.0
	Total	100	100.0

From table 1 it is observed that 13.9% of the Household Head are Illiterate, 18.8% Are Primary, 24.8% are HSLC, 20.8% are HS, 14.9% are Graduation, 4.0% are PG and 2.0% are others degree passed.

It is observed that the income of the family in the selected study subjects which range "Between" 10000 to 25000 is (67%) whereas 25000 and above is (33%).

Table2: Analysis for Chi-Square tests

Educational Level	Observed (O)	Expected (E)	O − E	(O − E)²	(O − E)² / E
Illiterate	14	14.29	-0.29	0.084	0.006
Primary	19	14.29	4.71	22.184	1.551
HSLC	25	14.29	10.71	114.704	8.027
HS	21	14.29	6.71	45.024	3.15
Graduation	15	14.29	0.71	0.504	0.035
PG	4	14.29	-10.29	105.884	7.411
Others	2	14.29	-12.29	151.044	10.574
Total	100	100			30.75

The calculated Chi-square value ($\chi^2 = 30.75$) exceeds the critical value (12.59) at 6 degrees of freedom and 5% significance level. Therefore, the null hypothesis (H_0) of equal distribution is rejected. This indicates that educational attainment is not uniformly distributed among the respondents.

4. Conclusion:

The study concludes that educational attainment among respondents is significantly uneven. The Chi-square test confirms that the observed distribution differs from a uniform pattern. While secondary education is relatively widespread, higher education participation remains limited.

Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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CRM Application in Managing Hotel, Restaurant and Tourism Services in Assam

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Abstract

Assam is starting to enter a new stage of development and integration, deeply integrating into the world economy with the completion of many large-scale free trade agreements. The development of integration shows how Assam tourism and hotel tourism enterprises have applied management and implementation methods to build strong resources and competitiveness in the current context. To do this, businesses are always in the spirit of strategic planning and in the spirit of solving problems related to customers, information and technology innovation. Experts said that Assam's tourism and hospitality industry promises to continue to grow when Assam is emerging. The above topic will bring some information about customer management solutions for tourism and restaurant services.

Keywords: *CRM, Service Management, Tourism, Restaurants, Hotels*

1. Introduction

Customer Relationship Management (CRM) is a strategic approach that enables businesses to systematically manage interactions with customers and improve communication effectiveness. It helps organizations collect, store, and analyze customer information, including business details, needs, and initial contact history, to deliver more professional and personalized services (Payne & Frow, 2005; Buttle & Maklan, 2019). Through CRM systems, customer data is centrally stored in a database management system, allowing enterprises to maintain updated and accurate records.

Moreover, CRM facilitates the classification of customers into categories such as potential customers, prospects, regular clients, and VIP customers, enabling businesses to design targeted customer care strategies (Kotler & Keller, 2016). It also allows organizations to respond quickly and efficiently to customer issues, enhancing satisfaction and loyalty. CRM systems further contribute to improving internal coordination by managing both customer and employee relationships effectively.

A successful CRM strategy includes not only technological implementation but also employee training, process adjustments, and the adoption of appropriate information technology systems (Chen & Popovich, 2003). By placing customers at the center of business operations and focusing on their needs, organizations can build strong relationships, improve customer retention, and ultimately achieve maximum profitability.

1.1 Theoretical Framework

The concept of CRM

CRM (Customer Relationship Management) is a method to help businesses access and communicate and create relationships with customers in a systematic and effective way, manage customer information such as account information, needs, and links to serve customers better. The best way to understand CRM is: the entire process of synthesizing and analyzing customer and sales information, the effectiveness of marketing, the ability to adapt to market trends. The purpose of improving business performance is to bring the highest profit for the company. CRM is also known as marketing by relationship or customer management. This is the term of the information technology Industry to talk about methods, strategies, software, or other forms based on database platform to help businesses organize and manage relationships with customers.

The purpose of CRM is to help businesses better understand their customers, their value and help businesses improve how to contact them. CRM has gradually replaced traditional marketing forms with basic 4Ps technology: Product, Price, Distribution Channel and Marketing. There are three main areas mentioned frequently when evaluating customer satisfaction: Business, Marketing and Services. Marketing focuses on sample customer analysis and optimal solutions that bring satisfaction to customers.

The concept of CRM appeared in the early 1970s, when business units showed many changes from concept of "product orientation" to "customer orientation". Customer Relationship Management is known as an outstanding process of handling, implementing and managing customers for an organization. The concept of managing original customer relationships is based on three major principles: Taking care of existing customers; expand future customers and increase asset value for all customers. The final CRM system appears to include all the complete information about a business, and the result of the company will increase sales and profits, improve customer satisfaction and loyalty.

For customers: CRM contributes to promoting long-term relationships between customers and businesses, helping customers understand better, being served more attentively, feeling interested in very small things like hobbies, needs and anniversary.

For businesses: CRM helps businesses listen to customers more, easily manage the business and development situation, help businesses promote products and brands quickly, easily and at the lowest cost. CRM is a tool to help businesses manage their resources and employees centrally.

For managers: CRM provides managers with many effective support tools, helping managers quickly analyze, assess the business situation of enterprises and detect risks to be able to timely propose appropriate solutions to solve the problem. At the same time, CRM also allows managers to assess the situation and performance of each lower-level employee.

For employees: CRM allows employees to effectively manage their time and work, helping employees understand information about each of their customers to provide quick, reasonable support methods. Be reputable and retain long-term customers. Depending on the large and small scale of

business areas, the CRM implementation process of businesses will be different. However, there are still basic steps:

- Set detailed requirements for each departmental department based on the general objectives initially set out in the CRM strategy.
- System design and integration, this is a time-consuming phase in deployment.
- Check the system: check the functions of the selected solution to serve the business needs to a certain extent, ensuring the system is operated smoothly.
- Training staff to exploit and use the system.
- Collect staff feedback, especially customer care as well as customer comments. On that basis, assess the operational results of the benefits that CRM brings.

1.2 Current State of Implementing CRM System in Assam

CRM is quite popular in the world. In Assam, CRM has not been paid attention and developed properly. Many Assamese enterprises are now aware of the importance of Customer Relationship Management but only interested in investment in technology solutions. Only a few businesses apply CRM on a large scale. The rest of businesses mostly apply at department level or incorporate CRM into one or more other projects. In Assam, CRM has been present for more than 15 years but is still a very new concept for the business community. Many businesses have not really understood CRM. Enterprises' awareness of the importance of CRM technology is still very limited. For a company to be efficient, cost-effective and easily manageable, CRM technology is very potential. The shyness and delay in the application of technology may make it difficult for Assamese enterprises to integrate with the global economy. Businesses all know CRM focuses on finding, selecting, building and maintaining relationships with customers. But, because CRM relates to customers, many people still think that only the business department needs CRM. This has led to mistakes in implementing and applying CRM. Due to the promotion, dissemination and supervision of the implementation of CRM vision to each department, employees do not work well, leading to the awareness and collaboration of each employee, middle-level leader, affecting the real CRM exam. Some businesses believe that ERP (enterprise resource management) must be internally applied and then think of CRM as external management. Meanwhile, the existence, growth or degradation of businesses all depend on customers. If it is waiting for strengthening internal resources and thinking about customers then it is too late. The competition does not wait for any one, should not think that large enterprises need to go to CRM, not small. Some businesses have not really placed customers in a central location. Because of focusing too much on technology and strategy, businesses have forgotten the central position of customers.

Some other businesses are too hasty in the process of implementing CRM on the enterprise side. If in the process of applying CRM, enterprises do not focus on training employees, they do not have full understanding in terms of concept, usage as well as how to implement CRM, therefore, it is more difficult to serve customers and not bring about success for businesses as expected. For customers, no matter which model the company applies, most importantly, they do not have to face

many obstacles in accessing information from the business and are provided with the best services. In Assamese enterprises, the full CRM strategy faces many difficulties. The assessment of the current position of the business in terms of value, loyalty and customer satisfaction is incomplete because of the lack of customer information. Customer value is largely assessed by sales while customer loyalty and satisfaction are almost impossible to assess. Setting up customer goals is largely vague, unclear. Most businesses are not interested in pointing out the requirements of people: skills, culture, organization, responsibilities and powers. The requirements for customer data are completely lacking and inconsistent based on existing discrete data of individual departments. While CRM needs a lot of information to rebuild business relationships with lost customers or build marketing plans or sales and service policies, providing information is often lacking and accuracy is not high to meet the requirements. Many businesses have not focused on building long-term, sustainable relationships with customers, but it is not clear that CRM is the bridge between businesses and customers, helping businesses understand the needs and capture information of customers are faster, more accurate. Besides, some businesses are too hasty in the process of implementing CRM. Some businesses in the application process have not focused on employee training, while employees have the best understanding of concepts, uses and how to implement CRM. CRM is a long-term strategy to help businesses achieve long-term goals.

Employees in some tourism businesses have not seen their importance and responsibility in building customer relationships. Research results show that in restaurants, visitors will be special. satisfied if the staff perform the following: Remember the name of the customer, greet the intimate guests, show their professional skills: Have knowledge about cuisine, understand the dishes, processing methods , the application of each dish, presentable to the guests of each dish, create comfort for guests according to the preferences and needs of each type of guests.

Of course, restaurant staff can only remember the names of long-stay guests, but the following two requirements can be made with professional and responsible employees. The reality shows that Assamese restaurants have not done so. The performance of employees is still formal and only according to responsibility. Many employees do not have knowledge of cuisine and do not master the operation of the restaurant. Not only that, but their service is still slow and wrong. This shows that employees are not yet oriented to customers. This may be due to the failure of the leader of the restaurant who has not yet thoroughly assigned them to see that they must target their customers, their responsibilities and their role in building relationships with customers, or they may not have been trained accordingly.

Information technology is very important in modern life today. Application of information technology helps us solve quickly and effectively many problems. But businesses operating in the tourism sector have not taken advantage of its capabilities in their operations, especially in customer relationship management. Many businesses think that having CRM software is really about managing customer relationships. In fact, CRM software only has its effect when businesses perform well in each step of customer relationship management. It is very difficult to find documents about CRM in

tourism. In all the issues from 2000 to the present of Assam Tourism Magazine, there has not been any article mentioning the management of the customer relationship. It shows that this issue has not been paid attention to businesses operating in the tourism industry. Here are some information about the status of customer relationship management in the tourism industry in Assam. We can see that this issue has not been properly concerned in the tourism industry. But in the current trend of economic integration, the biggest value of enterprises is customers. While businesses around the world consider a new philosophy of business, in which customers and customer relations are at the forefront, in Assam, in the tourism industry, an industry that requires keeping and retaining a relationship more than any other industry are not given proper attention. This gives us many questions

Most Assamese enterprises face 4 main difficulties in implementing CRM application: no standard business process; daily level and reporting skills of employees are poor, so are the sharing and coordinating work. The team spirit in the business is not good, most of the staff does not understand CRM, and so they do not know how to apply and deploy CRM and how to choose appropriate CRM software. A successful CRM project includes processes, policies, manpower, strategy and technology. Besides, there are a number of other factors that we need to be aware of to ensure success in deployment. Many deployment cases did not bring CRM to promise, simply because it was hindered by the dispersion of information and the separation between front-office CRM systems and back-office ERP applications.

2. Research Results and Discussions

Initially, CRM is just a simple contact information management system (CMS - Contact Management System), but over time, vendors aim to build a comprehensive CRM solution that includes activities. sales and marketing, and at the same time become an important 'extension' in helping businesses understand customers better, thereby providing information for product and service exchanges, helping to develop and retain customers. Goods and strategies to increase sales, as an enterprise operating in the field of services: tourism restaurants, hotels, certainly cannot care about the features and characteristics that CRM brings:

- Calendar management. Support identifying and scheduling interaction with customers or potential customers. The bottom line is that neither too early nor too late, timely contact will help to increase the ability to convert into real customers. With caregivers, this is a good feature to help manage contact support after purchase to help customers experience the best service from the business.
- Email marketing. With a customer database built overtime, the marketing team can perform email marketing campaigns for a variety of purposes (usually providing newsletters, or launching new features or chapters promotions, discounts), through which build continuous relationships with customers.
- Manage quotes and proposals (quote, proposal). Managerial quotes, suggestions for each customer or customer group automatically use the quoted price when making orders for customers, avoiding confusion in terms of information and professional image presentation.

- Integrated marketing automation. Automated repetitive tasks to improve marketing efficiency include campaign management and email management, reporting and analyzing leads, website optimization, creating landing pages and forms.
- Lead scoring. The feature shows the transition ability of a focal point through the assessment point, in order to have active contact and priority when caring.
- In addition to the most used floating features of CRM, during the strong development of industry 4.0, the collection of customer information from social networking sites and online information also contributed to the way compete and thrive among them, including 5 features that businesses most want from CRM:
- Follow social network (social listening). Knowing how your brand or product is being spread discussed on social networks, is extremely useful for businesses that regularly implement sales and advertising campaigns on these platforms.
- Social network profile (social profile). The other side of collecting customer information is to get a full picture of the customer, besides the information gathered through sales and marketing.
- Mobile application (mobile app). Due to increasing flexibility for users, most CRM providers today have or are planning to provide solutions on mobile platforms.
- Tracking customer. The higher the competition in a field, the more important the importance of customer care work, retaining customers who continue to use products or services is the ultimate task in today's business environment. Knowing the level of customer loyalty will help provide appropriate strategies to achieve this goal.
- Integrated e-commerce (e-commerce integration). This is an increasingly popular feature. For businesses to use, this is a feature that helps them take advantage of consumer habits and behavior of purchasing, combining them into the e-commerce platform, to enhance the experience of customers. With a solution provider, this feature helps them to outperform their competitors. It is also bait that attracts businesses to stick with their solutions.

Typically, CRM applications will be used by the following objects in the business, corresponding to each different purpose:

Sales team: Salespeople use CRM to record opportunities, calls as well as contact information, schedule contacts, track the status of potential customers to make sales efforts. The sales manager will use CRM to know which potential customer is in the buying phase (buying journey) and monitor the progress of sales. This process helps to identify sales staff who need additional training.

Marketing expert: Marketing experts will use the information obtained from CRM to better introduce enterprise products. Information in CRM provides insight into the market and segment. Marketing will have more time to focus on creative ideas to help find more clues.

Customer care: The goal of CRM helps businesses build relationships with customers better, and one of the activities to help achieve this goal is care. The care staff will rely on the recorded interactions on the CRM system to perform care, support, complaint recognition, troubleshooting, etc.

IT: Usually involves deploying CRM, performing updates or integrating CRM with other systems.

Finance: This object needs to access payment information or customer contracts (if available on CRM), as well as sales growth forecast data provided on CRM.

Personnel: Take notes and collect data to track employee performance and productivity in sales, marketing, or using CRM to track candidates for jobs instead of using other software for recruitment.

3. Conclusions and Recommendations

With the development of a market economy, supply greater than demand, in order to achieve profitability, businesses must have many measures to care about customers, because customers are the primary goal of enterprises, making How to attract new customers, retain old customers, require businesses to understand their tastes and always be willing to change and improve products accordingly. The forms of customer satisfaction by product quality and service quality during and after sale are also increasingly paid attention. Businesses that are able to meet customer needs are interested by customers, will stand firm on the volatile business market today. To do this, Assamese enterprises must constantly develop, in which the application of information technology to management activities is being paid attention to by companies and corporations. Understanding CRM customer management strategy as well as applying CRM software solutions is an inevitable trend that Assamese enterprises should invest and apply. Not only because CRM brings many benefits for businesses but also because CRM helps businesses enhancing their position in the hearts of customers and in the marketplace. Especially with the size of Assamese enterprises at present, the quality of products is not really respected, it is necessary to focus on caring for customers and listening to their voices. The application of the customer relationship management system in Assam today has been understood and applied by businesses. However, the application of CRM is still young and difficult. Therefore it is necessary for businesses to thoroughly understand and devote a reasonable resource to implement and deploying CRM to maximize the benefits it brings.

Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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Digital Fatigue among Students and Teachers in Higher Education: A Human-Centred Reflection

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Abstract

The increasing reliance on digital technologies has reshaped higher education in unprecedented ways. While digital platforms have ensured accessibility, flexibility, and continuity of learning, they have also introduced a less visible but deeply felt challenge digital fatigue. This paper offers a human-centred exploration of digital fatigue as experienced by students and teachers in higher education. Rather than viewing the issue purely as a technological problem, the study situates digital fatigue within everyday academic life, emotional well-being, and pedagogical practice. By examining its causes, manifestations, and long-term implications, the paper argues for a more balanced, empathetic, and sustainable approach to digital education.

Keywords: *Digital Fatigue, Higher Education, Teachers, Students, Online Learning, Well-being*

1. Introduction

In recent years, classrooms have quietly transformed. Chalkboards have given way to screens, lectures to video calls, and conversations to chat boxes. What began as a necessary shift during the COVID-19 pandemic has gradually become a permanent feature of higher education (Dhawan, 2020). Digital tools now shape not only how we teach and learn, but also how we think, feel, and engage with academic life (Selwyn, 2016). While technology has expanded educational possibilities, it has also created a new form of exhaustion known as digital fatigue (Bailenson, 2021). Students attend multiple online classes in a day, submit assignments through portals, and remain constantly connected (Aristovnik et al., 2020). Teachers design digital content, attend virtual meetings, evaluate online assessments, and respond to messages beyond working hours (Rapanta et al., 2020). Over time, this continuous engagement takes a toll that is often unnoticed and unacknowledged (Wiederhold, 2020). This paper explores digital fatigue as a lived academic experience rather than a technical inconvenience.

1.1 Understanding Digital Fatigue

Digital fatigue is not a sudden or dramatic breakdown, but rather a gradual erosion of attention, energy, and emotional resilience. It develops subtly as individuals spend increasing amounts of time navigating screens, digital platforms, constant notifications, and virtual interactions (Mark et al., 2018; Larry D. Rosen et al., 2013). Unlike physical fatigue, which can often be alleviated through rest, digital fatigue tends to persist even after breaks, as the mind remains over stimulated and mentally engaged (Gloria Mark et al., 2018).

The continuous demand to process visual information, interpret digital cues, and maintain responsiveness places a significant cognitive burden on individuals (Daniel J. Levitin, 2014). Online environments frequently require multitasking such as listening to lectures while checking messages, reading slides, or responding to emails which further intensifies mental exhaustion (Clifford Nass et al., 2009). Over time, this constant switching between tasks diminishes the brain's capacity for sustained attention, deep focus, and reflective thinking (Levitin, 2014).

In addition to its cognitive effects, digital fatigue also has a strong emotional dimension. The absence of face-to-face interaction can foster feelings of isolation, detachment, and reduced motivation (Sherry Turkle, 2015). When academic engagement is mediated primarily through screens, both learners and educators may experience a sense of disconnection from the human presence that traditionally underpins meaningful educational experiences (Turkle, 2015; World Health Organization, 2020).

1.2 Causes of increasing Digital Fatigue

Prolonged screen engagement

The shift to digital education has significantly altered daily academic routines. Students often attend back-to-back online classes, followed by hours spent completing assignments, watching recorded lectures, or preparing presentations. Teachers, similarly, spend extended periods designing digital content, reviewing submissions, and attending virtual meetings. This prolonged screen exposure affects both physical and mental health. Limited movement, poor posture, and continuous visual focus contribute to headaches, eye strain, and musculoskeletal discomfort. More subtly, constant screen engagement reduces opportunities for informal learning moments such as corridor conversations, spontaneous discussions, or reflective pauses that once enriched academic life. As screens replace physical spaces, academic work becomes increasingly sedentary and mentally compressed, leaving little room for recovery or creative thought.

Monotony in Digital Teaching

Digital platforms often encourage uniform teaching methods. Long lectures delivered through video conferencing tools, slides shared on screens, and limited student participation can create a monotonous learning environment. Without physical presence, teachers struggle to read body language, facial expressions, or emotional cues, making it difficult to adapt teaching strategies in real time. For students, passive listening over extended periods demands sustained concentration without the natural variation provided by classroom interaction. This monotony increases cognitive load, making learning feel effortful rather than engaging. Over time, students may associate online learning with boredom and exhaustion rather than curiosity and intellectual growth. The lack of sensory variety movement, voice modulation, group activity further deepens digital fatigue, turning learning into a repetitive and draining experience.

Blurring of academic and personal life

Digital education has disrupted traditional boundaries between academic and personal spaces. Homes have become classrooms, offices, and examination halls. While this flexibility offers convenience, it also eliminates clear distinctions between work and rest. Teachers often feel compelled to respond to emails, messages, and academic queries beyond official working hours. Students, similarly, experience pressure to remain constantly available and productive. The absence of temporal boundaries leads to a sense of perpetual academic engagement, leaving little time for mental recovery. This continuous connectivity fosters guilt during rest and anxiety during downtime, reinforcing fatigue and emotional strain.

Psychological pressure to perform digitally

Digital competence has become an unspoken expectation in higher education. Teachers are often required to adapt to new platforms, tools, and assessment methods with minimal training or support. Fear of technical failure, reduced student engagement, or perceived inadequacy contributes to professional anxiety. Students, on the other hand, face pressure to meet digital deadlines, navigate learning management systems, and perform consistently in online environments. Technical glitches, internet instability, or lack of digital literacy can trigger stress and feelings of helplessness. This psychological pressure, combined with constant evaluation and comparison, accelerates burnout and deepens digital fatigue.

1.3 Digital fatigue among students

Digital fatigue alters the way students experience learning. Instead of active engagement, many resort to surface-level participation in logging into classes without emotional or intellectual involvement. Reduced attention spans make it difficult to follow complex discussions or retain information. Emotionally, students may feel disconnected from peers and instructors, weakening their sense of belonging. Prolonged isolation, combined with academic pressure, increases vulnerability to anxiety and emotional exhaustion. For students facing economic or technological constraints, digital fatigue is compounded by frustration and inequality. Limited access to stable internet or private study spaces turns learning into a constant struggle, reinforcing educational disparities. Digital fatigue affects both academic performance and emotional health. Many report reduced attention spans, declining motivation, and difficulty retaining information. Learning becomes mechanical rather than meaningful.

In addition, prolonged screen exposure disrupts sleep patterns and physical health. Students from disadvantaged backgrounds face added challenges such as poor internet connectivity, shared devices, and unsuitable study environments, intensifying fatigue and frustration.

Digital fatigue, therefore, widens existing inequalities in higher education.

1.4 Digital Fatigue among Teachers

Teachers often experience digital fatigue silently. Preparing online content, managing digital platforms, attending virtual meetings, and addressing student concerns require sustained cognitive and emotional labour.

The absence of direct classroom interaction reduces teaching satisfaction and makes it harder to gauge student engagement. Over time, this leads to professional burnout, reduced creativity, and emotional exhaustion. The expectation to continuously adapt without adequate institutional support further intensifies this fatigue. Teaching in digital environments requires sustained emotional labour. Teachers must motivate students through screens, manage silence in virtual classrooms, and maintain enthusiasm despite limited feedback. The absence of immediate student response often creates self-doubt and emotional disconnection. Administrative responsibilities have also increased, with digital documentation, reporting, and monitoring adding to workload. Many teachers experience fatigue not only from teaching itself but from the constant adaptation required in digital systems.

Over time, this cumulative strain reduces professional satisfaction, creativity, and pedagogical innovation, leading to burnout.

1.5 Post-pandemic Continuity of Fatigue

Even after the reopening of physical classrooms, digital fatigue has not disappeared. Hybrid teaching models, online documentation, and digital assessments continue to dominate academic practices. What was once temporary has become routine, often without reflection on its long-term impact. This persistence highlights the need to critically evaluate how much technology is necessary and how much is excessive.

1.6 Pedagogical and Emotional Implications

Digital fatigue affects the quality of teaching and learning. Students become passive recipients of information, while teachers struggle to maintain engagement. Emotional disconnect replaces intellectual curiosity. Education, at its core, is a human process. When learning becomes overly digitised, it risks losing empathy, dialogue, and relational depth.

1.7 Human-Centred Strategies to Overcome Digital Fatigue among Teachers and Students

Digital fatigue cannot be addressed through technical solutions alone. Since it affects attention, emotion, motivation, and identity, responses must also be human, compassionate, and context-sensitive. Both teachers and students need not only strategies, but permission—to slow down, to disconnect, and to acknowledge fatigue without guilt. Addressing digital fatigue requires collective responsibility. At the individual level, students and teachers must practice digital self-regulation, take screen breaks, and prioritise physical and mental well-being. At the pedagogical level, teaching strategies should include shorter sessions, interactive elements, reflective activities, and offline learning components. At the institutional level, policies should acknowledge digital fatigue as a genuine concern. Reasonable workloads, wellness initiatives, and faculty support systems are essential.

2. Suggestions for Teachers

i. **Limit Continuous Screen Time**: Teachers should avoid long, uninterrupted online sessions and allow natural pauses during classes. Continuous screen exposure drains attention and energy, whereas shorter sessions with breaks help both teachers and students remain mentally present and emotionally engaged.

ii. **Prioritise Meaningful Engagement over Content Coverage**: Rather than rushing to complete syllabi, teachers can focus on key ideas and meaningful discussion. When learning emphasises understanding and reflection, it reduces pressure and makes digital education more sustainable.

iii. **Introduce Variety in Teaching Methods**: By using a mix method of synchronous and asynchronous activities, offline readings, and reflective tasks breaks the monotony of screen-based learning. Variety helps maintain curiosity and prevents learning from becoming mechanically exhausting.

iv. **Acknowledge Digital Fatigue Openly**: When the teachers recognise fatigue as a shared experience, students feel seen and understood. This openness reduces emotional distance and creates a more supportive and humane learning environment.

v. **Set Clear Digital Boundaries**: Defining specific hours for online communication helps prevent constant connectivity and emotional exhaustion. Clear boundaries protect teachers' well-being while also teaching students the importance of balance.

vi. **Seek Institutional and Peer Support**: Teachers should be encouraged to share challenges, seek training, and collaborate with colleagues. Institutional recognition of digital labour helps reduce burnout and fosters professional resilience.

3. Suggestions for Students

i. **Recognise Early Signs of Fatigue**: Students should become aware of physical and emotional signals such as loss of concentration, headaches, or irritability. Early recognition allows timely rest and prevents deeper exhaustion.

ii. **Take Regular Screen Breaks**: Short breaks between classes, eye relaxation, and physical movement help restore focus and reduce strain. These small practices significantly improve mental clarity during long academic days.

iii. **Create Boundaries Between Study and Rest**: Establishing fixed study hours and designated learning spaces helps separate academic work from personal life. This separation supports emotional recovery and prevents constant mental engagement.

iv. **Engage Actively in Learning**: Active participation through discussion, note-taking, and questioning enhances attention and reduces monotony. Meaningful involvement makes learning feel purposeful rather than draining.

v. **Maintaining Healthy Daily Routines**: Regular sleep, balanced nutrition and physical activity play a vital role in managing digital fatigue. A healthy routine strengthens resilience against prolonged digital exposure.

vi. **Seeking Support Without Guilt**: Experiencing digital fatigue is common and does not reflect a lack of ability. Seeking help from peers, teachers, or support systems promotes emotional well-being and academic continuity.

4. Shared Responsibilities for both Teachers and Students

i. **Rebuild Empathy in Digital Classrooms**: Understanding each other's challenges fosters patience and compassion. Empathy restores the relational dimension that digital learning often weakens.

ii. **Encourage Open Conversations on Well-being**: Honest dialogue about stress and exhaustion normalises care and reduces feelings of isolation. Such conversations strengthen academic communities.

iii. **Use Technology Intentionally, not Excessively**: Digital tools should be chosen thoughtfully to serve learning goals rather than convenience alone. Intentional use reduces overload and enhances educational quality.

iv. **Value Rest as Part of the Learning Process**: Rest and reflection are essential for creativity, memory, and intellectual growth. Recognising rest as productive supports sustainable higher education.

5. Conclusion

Digital fatigue has emerged as one of the most understated yet deeply influential consequences of the growing dependence on digital technologies in higher education. It is not merely a by-product of screen time, but a reflection of how academic life has been reorganised around continuous connectivity, efficiency, and digital performance. For both students and teachers, this fatigue shapes daily experiences of learning and teaching, often reducing motivation, emotional engagement, and a sense of belonging within academic spaces.

The findings discussed in this paper suggest that technology itself is not inherently detrimental to education. Rather, digital fatigue arises from uncritical and excessive use of digital tools without adequate consideration of human limits.When digital platforms dominate academic routines without space for rest, reflection, and interpersonal connection, education risks becoming emotionally distant and cognitively overwhelming. In such contexts, learning may continue, but its quality and meaning are gradually diminished.

Recognising well-being as central to educational quality is therefore essential. Higher education cannot be sustained through productivity and efficiency alone. Mental health, emotional balance, and physical well-being are integral to effective teaching and meaningful learning. Addressing digital fatigue requires moving beyond individual coping strategies toward collective responsibility, where institutions, educators, and learners acknowledge fatigue as a structural issue rather than a personal failure.

The persistence of digital fatigue in post-pandemic academic environments highlights the urgent need for reflection. As digital practices become permanent features of higher education, decisions about their use must be guided by care, empathy, and ethical responsibility. Convenience and technological advancement should not overshadow the relational and human dimensions of education, which remain at its core.

Ultimately, this paper calls for a more conscious and humane approach to digital education one that balances technological innovation with compassion, flexibility, and respect for human rhythms. Digital tools should serve as supports for learning, not sources of exhaustion. By placing well-being, connection, and empathy at the centre of digital transformation, higher education can move towards a more sustainable, inclusive, and human-centred future.

Declarations

Conflict of interest: The authors declare that they have no conflict of interest.

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