

Effect of Existing Teaching of Chemistry on Ninth Graders' Achievement in Sindh, Pakistan

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Abstract

Multiple studies have studied and hinted towards different flaws in teaching and learning: limited resources (Dahar & Faize, 2011; EdQual, 2007; Naseer-ul-Din, Iqbal, Khaleeq, & Rehman, 2010; Soomro, 2009); low/poor quality teaching and teachers and lack of proper professional teaching standards/accreditation (Government of Pakistan, 2009a, 2009b), corporal punishment (Government of Pakistan, 2007; Sarwar, & Hussain, 2010; The Express Tribune, January 14th, 2012), ineffective professional trainings (Ahmed, Azeem, Khalid, Farrukh, Ahmed, & Ahmed, 2012; Gujjar, Bajwa, Shaheen, & Rehman, 2011; Mehrunnisa, 1998; Saeed, 2007; UNESCO, 2011-12), uncompetitive traditional teaching (Hussain, Ahmed, Muben, & Tariq, 2011; Nazir & Naqvi, 2012), erroneous examination system (Hoodbhoy as cited in Christie & Afzaal, 2005), no difference between trained and untrained teachers (Khurshid, 2008) etc. Therefore, we empirically investigated the assumption whether existing teaching fails to inculcate the required knowledge and comprehension of the curricula among learners. This study, from learners' perspective, assessed the effects of professional teaching of chemistry on students' learning outcomes against the criteria of B.Ed. at public secondary schools in Pakistan. The professional teaching aspects were: general professional teaching skills, lesson planning, teaching methods, audio-visual aids, students' classroom activities and formative assessment, and course coverage of theory and practice. We collected quantitative data through self-developed questionnaire of 70 items using stratified sampling of 350 students from boys-only, girls only, boys in co-education, and girls in co-education across rural and urban schools. A panel of experts and pilot testing refined the tools. The overall Cronbach alpha value was 0.9 and 0.8 for professional teaching and test-items respectively. Descriptive statistics revealed the failure of existing professional teaching of chemistry because chemistry teachers mostly used dictation of questions and answers and somewhat lecture method; they did not plan for their lessons; they used only black-board as audio-

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visual aid; copying or writing questions and answers remained dominated as students' classroom activity; seldom question-answer remained formative assessment tool; and practical component remained untouched mostly. Multiple linear regression analyses revealed that the laboratory experimentation, audio-visual aids, chemistry theory, and teaching methods strongly predicted students' test-scores ($R = .645$) with 41.7% surety. However, demographic variables: students' favorite subject, home study, parents' income and students' gender weakly predicted learners' test-scores. Independent samples *t*-test and ANOVA analyses revealed that students devoting more time to home-study and tuition especially in natural sciences, students from separate boys-only and girls-only schools, and from parents with higher earning and rank got significantly different and better test-scores; however, gender and parents' education had no significant differences. We presented feasible and realistic recommendations.

Keywords: Evaluation, Teaching of chemistry, B.Ed., Professional training, Secondary schools

Introduction

Because chemistry is the backbone of many manufacturing/processing industries and one of the fundamental disciplines of many professional degrees related to the health sciences and pharmaceuticals, it is necessary to evaluate periodically the quality of teaching and learning of chemistry at secondary level from where it is taught as a separate discipline. Different institutions/authors (Agrawal, 2008; AIOU, 2012; ASKe & Oxford Brookes University, 2005; Baehr, n.d.; Lorien Eck, 2006; National Oceanic & Atmospheric Administration, NOAA, 2009; National Open University of Nigeria, 2006; National Science Foundation, 2002; Navarro Coy, 2009; Rust, O'Donovan, & Price, 2005; Stern, 2004; Suskie, 2009; Taras, 2008; Teach for America, 2011; The Saskatchewan Ministry of Education, 2008; University of Sydney, 2002) have given many forms of evaluations on the basis of involving different stakeholders and things like self, students, peers, alumni, employers, administrators, and teachers; teaching scholarships, awards and portfolios; and beneficiaries' learning outcomes. Since students are the actual beneficiaries and we do not have the required and reliable culture and infrastructure, therefore, we evaluated teaching of chemistry with relation to the criteria of B.Ed. that is the minimum required professional degree for the induction as a secondary school teacher in Pakistan.

The quality of teaching and learning in Pakistan has been questionable at all levels for a long time, and science education is no exception in this regard. Government of Pakistan (2009a) while discussing key issues of teacher education pointed out: "There is general consensus that quality of teachers is abysmally low" (p. 8). In our context, the previous studies can be classified into two broad categories (a) determining cause and effect of new psychological constructs involving teaching methods or students' activities while comparing them with traditional teaching or learning, and (b) evaluating existing teaching and learning against specific criteria.

Regarding first aspect, different researchers have found that for teaching of sciences existing (lecture) teaching cannot compete with inquiry based teaching i.e. guided, unguided, and a mix of guided and unguided inquiry (Hussain, Azeem, & Shakoor, 2011, p. 273); lecture-demonstration and laboratory method (Watkar, 2012, p. 2; Soomro, 2009, pp. 82-83); laboratory experimentation (Veselinovska, 2011, p. 183; Dahar & Faize, 2011); project method (Hussain, Ahmed, Muben, & Tariq, 2011, pp. 23-34); educational technology (Suleman, 2011, p. 116); computer simulations and guided discovery method (Udo & Etiubon, 2011, p. 211); and problem-based method (Akinoğlu & Tandogan, 2007, p. 71; Yaman, 2005, pp. 31-32).

Regarding second aspect, different authors have found different weaknesses in our traditional teaching and learning: low/poor quality teaching and teachers and lack of proper professional teaching standards and accreditation (Government of Pakistan, 2009a, 2009b); limited resources (Dahar & Faize, 2011; EdQual, 2007; Khurshid, 2008; Naseer-ul-Din, Iqbal, Khaleeq, & Rehman, 2010; Soomro, 2009); corporal punishment (Government of Pakistan, 2007; Sarwar, & Hussain, 2010; The Express Tribune, January 14th, 2012), ineffective pre and in-service trainings (Ahmed, Azeem, Khalid, Farrukh, Ahmed, & Ahmed, 2012; Gujjar, Bajwa, Shaheen, & Rehman, 2011; Mehrunnisa, 1998; Saeed, 2007; UNESCO, 2011-12), uncompetitive traditional teaching (Hussain, Ahmed, Muben, & Tariq, 2011; Nazir & Naqvi, 2012; Sarwar & Hussain, 2010), erroneous examination system (Hoodbhoyas cited in Christie & Afzaal, 2005), no difference in teaching of trained and untrained teachers (Khurshid, 2008).

Above studies were conducted with relation to different disciplines and professional criteria. No study was available in Pakistani context which evaluated the teaching of chemistry against the professional criteria of B.Ed. with relation to their effect on students' learning outcomes through reliable achievement test where there is no question of using unfair means on the part of students. Therefore, we evaluated the teaching of chemistry against the professional criteria of B.Ed. and determined their effect on students' learning outcomes. It is the first attempt in the context of Sindh, Pakistan which has investigated this issue through a representative sample (stratified random sample) from boys-only, girls-only, boys in co-education, and girls in co-education schools across gender and rural and urban location.

The aspects of teaching of chemistry which this study investigated were: (a) general professional teaching skills (regularity, punctuality, clarity of voice and handwriting, mastery on subject, intimacy to students, clear directions, equal and fair attitude to learners, fulfillment of special needs of special children, development of curiosity among learners, sense of humor, allowance to do mistakes while learning, quick and happy response to learners' questions); (b) lesson-planning (written or mind planning,

flexibility, assessing and relating students' previous learning to new topic, balance between teachers and students activities and time); (c) teaching methods (lecture, demonstration, laboratory, inquiry, project, field-trip, discussion, problem-solving, role-play, dictation, punishment); (d) audio-visual aids (board/chalk, charts, real things, models, projectors, computers and modern resources); (e) students' classroom activities (silent-reading, individual and group work, students' presentations etc); (f) students' formative assessment (verbal questions, quizzes, tests, home-work, assignments) and (g) coverage of prescribed course (theory and practical components).

Moreover, we extensively determined the effect of ten demographic predictors on the students' learning outcomes. They were: (a) gender, (b) type of school (boys-only, girls-only, co-education), (c) location (rural/urban), (d) parents' income, (e) parents' occupation, (f) parents' education, (g) students' home-study, (h) private tuition, (i) tuition-subjects, and x) favorite subject. The specific objectives of the study were:

- To assess the worth of prevailing pedagogical practices for teaching of chemistry against the criteria of B.Ed. at the above level, from learners' perspective.
- To examine the association between students' test-scores and above eight aspects of professional teaching of chemistry.
- To determine the relationship between students' test-scores and above ten demographical aspects.
- To find out difference between students' test-scores and above demographical aspects.
- To suggest the concerned stakeholders of taking proper corrective measures within available human and material resources for providing better quality education.

Research Methodology

This is part of a comprehensive mix study, but due to the space limitations the quantitative part is reported in this paper. Presently many authors suggest integrating both qualitative and quantitative approaches for getting more holistic picture and deeper understanding a phenomenon (McCall & Bobko, 1990, p. 8; Eisenhart & Howe, 1992; Currall, Hammer, & Baggett, 1999, p. 8; Myers & Barnes, 2005, p. 4; Bryman, 2006; Curry, Nembbard, & Bradley, 2009). Proper triangulation of both types of data not only neutralizes the flaws of the either to reap the strengths and benefits of the two (Hussein, 2009, p. 1), but it also ensures more confidence in the conclusions by adding broader and deeper understanding and analysis (Fielding & Schreier, 2001, para, 35 & 53; Thurmond, 2001, p. 257).

Here, we discuss only about the quantitative data collected through students' questionnaires and related sampling. Quantitative data were collected from 350 students of public secondary schools of District Jamshoro, Sindh through stratified random sampling drawn from the population of 3, 864 students (Figure 1 presents the population and sample drawn). Overall, the drawn sample implicated 9.1% of the total population which involved 209 males and 141 females accounting for a total of 69 rural and 281 urban respondents. It constituted four strata of students i.e. boys-only (161), girls-only (119), boys in co-education (48), and girls in co-education (22) schools across rural and urban respondents. Moreover, the sample comprised true proportion of Sindhi (305) and Urdu (45) medium students respectively; however, this aspect was not analyzed independently (Table 1 presents the tabular form of this sample). The size of sample was calculated according to Johnson and Christene (2000) which different researchers (Majid, 2012, pp. 86-89 etc) use presently in educational research. Fig. 1. and Table 1 represent population and sampling:

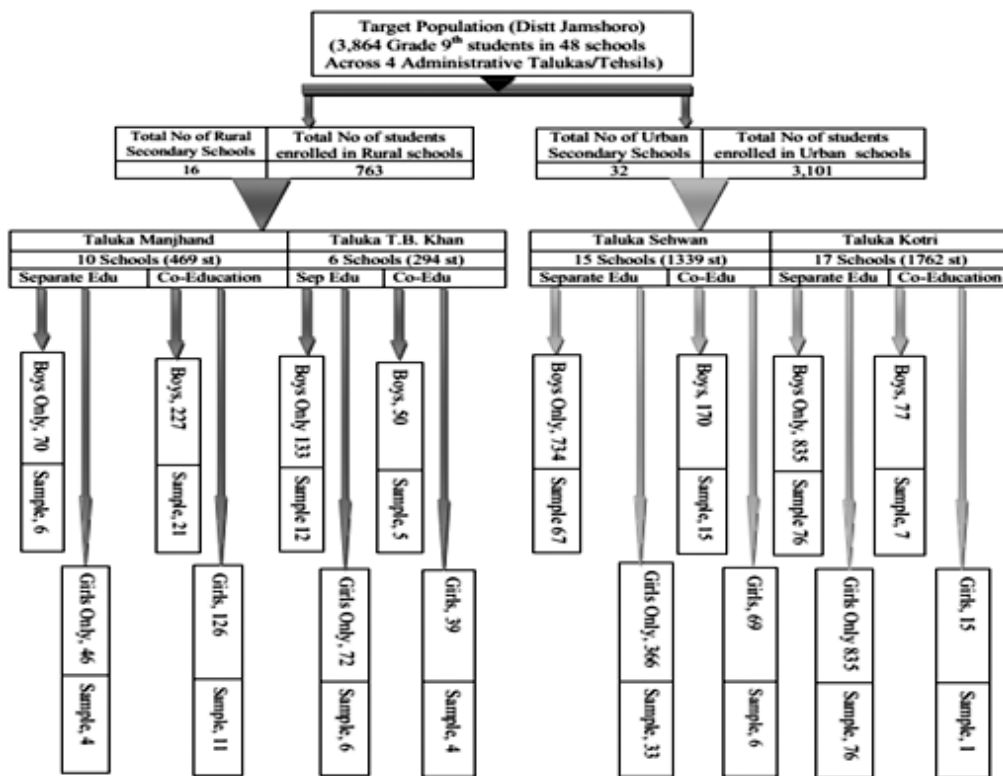


Figure 1. Target Population and Stratified Random Sampling (9.1%) Drawn

Table 1
Sample Statistics

Gender	Strata				Total
	Boys-only	Girls-only	Boys in co-ed	Girls in co-ed	
Rural	18	10	26	15	69
Urban	143	109	22	7	281
Overall Percentage	46%	34%	13.7%	6.3%	100%
Overall Total	161	119	48	22	350

Procedure

Phase 1. The researcher reviewed the related literature about teaching of sciences with special focus on different teaching methods, strategies, activities, and resources used for better teaching and learning at our local, national, and international context. It resulted in defining and framing the research problem, questions, and methodology of the present study.

Phase 2. Secondly, the researcher thoroughly reviewed the curricula of professional degrees i.e. B.Ed offered by the University of Sindh (Hyderabad) and Allama Iqbal Open University (Islamabad) to find out the specific pedagogical content and criteria for teaching of science related disciplines. Additionally the researcher reviewed the National Professional Standards for Teachers designed and prescribed by Ministry of Education, Government of Pakistan as general guidelines for teachers' evaluation (it is not reported in this paper). Moreover, the researcher conducted document analysis of the teachers' academic and professional qualifications and experience through the seniority list of all existing high school teachers including science-teachers of district Jamshoro (Sindh).

Phase 3. Thirdly, we designed the research tools i.e. five-point Likert-scale items of students' questionnaire and achievement test (and mind-map of semi-structured interviews-not reported in this study) and then pilot-tested them. The researchers sought help from three experienced professors of Iqra Universtiy, Karachi and two language experts of Sindhi and Urdu for translation of students' questionnaire using the technique of back-translation from English to Sindhi and Urdu and vice versa for ensuring validity.

Phase 4. Fourthly, quantitative and qualitative data were collected

Phase 5. Finally, data were analyzed through multiple regression, independent samples t-test, and analysis of variance (ANOVA). We used 95% confidence interval ($p < .05$) to reject the null hypotheses; currently, many researchers use it in social and psychological studies. Then, the results were reported.

“Questionnaires are most effective when used in conjunction with other methods, especially one or more varieties of interview technique” (Grix, 2010, p. 129). The researcher could not find relevant research tool that could meet the local requirements of evaluation teaching learning situation of the teaching of chemistry at secondary school level (grade 9th) within the framework of professional degree of B.Ed. in Pakistan. “In the development of the questionnaires, particular attention was given to ensure that questions are unambiguous, unbiased, unloaded, relevant, succinctly conceptualized as well as avoiding vagueness.” (May as cited in Ogunmade, 2011, pp. 67-68).

Under the above guidelines, we took the responsibility of designing the appropriate and required tool. The questionnaire involved demographics, students’ achievement test, and eight areas of professional teaching of chemistry. The demographic data included the gender, school-type, parent(s) occupation and income, after-school tuition hours, home study, and favorite subjects. Secondly, the chemistry-achievement-test comprised 18 objective-type questions with equal MCQs and blanks. Lastly, professional teaching of chemistry implicated eight parts: general professional teaching skills (12 items); lesson planning (7 items); teaching methods (13 items); audio-visual aids (6 items); students’ classroom activities (4 items); formative assessment (4 items); and course coverage (6 items).

The questionnaire assessed students’ responses against five-point Likert scale items except for demographics and test-items. The items of general professional teaching skills and lesson-planning involved the options of strongly disagree, disagree, neutral, agree, and strongly agree. All other parts implicated the options of never, rarely, sometimes, often, and always except the items of course coverage of theory and practical which included the options of 0%, up to 25%, up to 50%, up to 75%, and up to 100%. The questionnaire was translated into Sindhi and Urdu with the help of personnel having expertise in related languages. They were further refined as a result of piloting.

The malpractices within the Pakistani public sector assessment and examination system especially in Sindh are too common to solely depend on annual results. Media reports reflect serious flaws during annual examination days. Therefore, the researchers decided to administer valid and reliable achievement test to the 9th graders in their presence. Due to better reliability and objectivity in scoring, it was decided to administer objective type test.

The syllabus of chemistry involved two parts: part I (basic concepts of chemistry) and II (industrial application of chemistry) with 10 and 8 chapters respectively, now available in single book too. We designed an objective type test with 18 questions (9 each for MCQs and blanks). It covered the basics of all chapters of the first part of textbook i.e. chapters 1 through 10. It involved almost 2 questions (1 each for MCQ and blank) from each chapter. We selected the items from self-assessment exercises given at the end of chapters. Since the test-items were not researcher-made (but were made by experts and developers of chemistry curriculum) therefore it, on the one hand, not only saved the time and energy but added to the better validity and reliability, on the other hand. The items were selected on the knowledge and comprehension levels of Bloom's cognitive domain.

We assumed that the existing professional teaching of chemistry at our local (Sindh province) level was simply a failure and the public sector teachers did not and could not inculcate the understanding of the basic concepts of chemistry. We thought if this assumption was true then a clear majority of students would surely not provide the correct answers to the questions; otherwise, the students would get maximum scores on the test (the assumption was fully supported and related descriptive statistics showed failure of existing teaching of chemistry, but they are not part of this paper). The test items were embedded in the students' questionnaire as first part out of eight parts responded to by all (350) students of the sample.

Response Rate and Analysis of Data

We personally administered the questionnaires and the respondents filled them on the spot in our presence (facilitation/guidance of the researchers wherever necessary). It served three benefits i.e. clarity of respondents' doubts and ambiguities, enhanced willingness to participate, and perfect (100%) response rate.

Validity and Reliability of the Tool

The face validity is a judgment and consensus of the research fraternity that the definition and the measurement fit properly. The content validity is making the measurement tool representative of all the ideas and areas of targeted content (Neuman, 2007, pp. 117-118).

After designing the questionnaire including achievement test items, we presented it to three experts of Iqra University, in the field of education, for determining face validity. Moreover, the questionnaire was pilot tested on 15 randomly selected relevant respondents that were not included in the actual study. It further refined the instrument in terms of removing ambiguity and getting more clarity of meaning from the respondents' perspective.

As mentioned above the content validity works like a stratified sampling that ensures proper representation of all the areas in proper proportion within a measuring tool. For this purpose, we made the eight areas of our Likert scale items and students' achievement test-items representative of the professional teaching criteria of B.Ed. and the first part of chemistry textbook (chapter 1-10) respectively.

There is always some extent of error in measurement therefore it is necessary to calculate the level of error in research tools to make them more valid and reliable. Typically researchers use Cronbach's alpha coefficient to calculate the internal consistency of a measurement tool scored by ratings (1, 2, 3. . .) pertaining to unidimensional trait (Tan, 2009, p. 102).

Therefore, we used Cronbach's alpha for each part of questionnaire to determine its internal consistency through SPSS package 16.0. We calculated it for both components of the questionnaire i.e. the items of chemistry achievement test and five-point Likert items of the questionnaire. The chemistry test involved 18 objective type items (9 each for MCQs and blanks). The Cronbach's alpha values were found to be 0.7 for MCQs, and 0.9 for Blanks, with an overall alpha value of 0.8 showing considerable/acceptable internal consistency.

Regarding eight parts of the questionnaire, the Cronbach's alpha values stood at: 0.9 for general professional teaching skills (12 items); 0.6 for each lesson planning (7 items) and teaching methods (13 items); 0.7 for audio-visual aids (6 items); 0.6 for students' activities (4 items), 0.8 for students' formative assessment by teacher (4 items); 0.6 for course coverage of theory (3 items); and 0.8 for course coverage of practical (3 items). The overall Cronbach's alpha value for the questionnaire used in this study was found to be 0.946 which explicitly indicates excellent internal consistency.

Ethical Considerations

Neuman (2007) points out, "Social research can harm a research participant in several ways: physical, psychological, and legal harm, as well as harm to a person's career, reputation, or income" (p. 51). According to Grix (2010), issues of harm to respondents, informed consent, and respondents' confidentiality are crucial for a social-sciences researcher (p. 145). We sought legal (letter from Iqrauniversity, and Director of Schools Hyderabad) and informed consent for the present study. We did not reveal the names of respondents and their schools during data collecting and reporting to avoid any legal, social, and political harm. In this regard the present study ensured maximum anonymity and complete confidentiality.

Results

Professional Training

According to the male and female teachers' seniority-lists of District Jamshoro, Sindh for the year of 2012, there were 452 secondary school teachers. It involved 356 male and 96 female secondary school teachers (known as high school teachers, HSTs). They all were professionally trained and had B.Ed. degrees on their credit; however, 75% of the teachers across male and female teachers possessed advanced professional degree of M.Ed.

Descriptive Statistics (Overall of Eight Variables)

No single aspect of teaching of chemistry corresponded to better findings of descriptive statistics. Descriptive statistics showed poor professional teaching throughout. General professional teaching skills got relatively better mean scores ($M=3.5$) than other variables, followed by course coverage of chemistry theory ($M=2.74$). Audio-visual aids ($M=1.61$) and course coverage of the practical component that all the secondary school teachers except for a few did not show proper general professional teaching skills; did not plan their lessons; did not teach through laboratory experimentation, inquiry, project, picnic (observation), discussion, problem-solving, and role-play teaching methods; did not use charts, real things (elements and compounds), models, projectors, and modern technology related things (computer and internet); did not engage their students in group-work, individual exploration and presentations; did not assess students learning through short quizzes, MCQs, and assignments/home-work; did not cover the second theoretical part (chapter 11 to 18); and did not even bother to touch the practical component.

Contrastingly, they only dictated the textual questions and answers to their students; they mostly depended on blackboard and chalks; and they could not go beyond rare verbal questions in assessing students' learning. Therefore, the researcher finds a solid base to conclude that overall teaching of chemistry at public secondary schools of Sindh (Pakistan) deviates from the professional criteria of B.Ed. in terms of above eight aspects of teaching of chemistry got the least mean scores while the others also fell within disagreement followed by teaching methods ($M=2.05$), lesson planning ($M=2.24$), students' classroom activities ($M=2.52$), and students formative assessment by the teachers ($M=2.35$). The descriptive means of all above variables except general professional teaching skills either correspond to clear "disagreement" or tilt toward it. Extremely lower students' mean scores in test items, especially blanks, ($M=3.56$ for MCQs and $M=0.93$ for blanks) out of total 18 marks explicitly indicated that students lack

in basic conceptual knowledge and understanding of the text. Table 6 presents related descriptive statistics of the eight variables of professional teaching of chemistry.

Table 6
Descriptive Statistics (Overall)

Variable	<i>N</i>	Minimum	Maximum	Mean		<i>SD</i>
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
MCQs (Achievement test)	350	0	9	3.56	.100	1.874
Blanks (Achievement test)	350	0	8	.93	.075	1.410
Overall (Achievement test)	350	.00	16.00	4.4914	.15063	2.81801
General professional skills	350	1.00	5.00	3.5919	.05188	.97062
Lesson planning	350	1.00	4.14	2.2433	.03639	.68084
Teaching methods	350	1.00	3.23	2.0512	.01951	.36505
Audio-visual aids	350	1.00	4.33	1.6124	.02878	.53847
Students' activities	350	1.00	5.00	2.5193	.04316	.80751
Formative assessment	350	1.00	5.00	2.3450	.05495	1.02795
Course coverage theory	350	1.00	5.00	2.7371	.04528	.84718
Course coverage practical	350	1.00	4.00	1.4552	.04668	.87324
Valid N (list-wise)	350					

The descriptive statistics revealed that all the secondary school teachers except for a few did not show proper general professional teaching skills; did not plan their lessons; did not teach through laboratory experimentation, inquiry, project, picnic (observation), discussion, problem-solving, and role-play teaching methods; did not use charts, real things (elements and compounds), models, projectors, and modern technology related things (computer and internet); did not engage their students in group-work, individual exploration and presentations; did not assess students learning through short quizzes, MCQs, and assignments/home-work; did not cover the second theoretical part (chapter 11 to 18); and did not even bother to touch the practical component. Contrastingly, they only dictated the textual questions and answers to their students; they mostly depended on blackboard and chalks; and they could not go beyond rare verbal questions in assessing students' learning. Therefore, the researcher finds a solid base to conclude that overall teaching of chemistry at public secondary schools of Sindh (Pakistan) deviates from the professional criteria of B.Ed. in terms of above eight aspects of teaching.

Regression Analyses

Regression model. While examining the scatter plots, the researcher found that there was some direct relationship between targeted independent variables and the students' achievement test-scores. Therefore, the researcher used multiple linear regression analysis to analyze and predict the effect of multiple independent variables (general professional teaching skills, lesson-planning, teaching methods, audio-visual aids, students' activities, formative assessment, and course coverage along with certain demographics) on the dependent variable (students' scores in chemistry achievement test). Since the multiple linear regression model is the extension of simple linear regression, therefore the model goes like this:

$$Y_i = B_0 + B_1 x_{1i} + e_i \dots \dots (1) \text{ (Simple Linear Regression)}$$

$$\text{Dependent (predicted)} = \text{Constant} + B_1 \text{ Independent}_1 + \text{Error term}$$

Since there were eight independent variables in the present study, therefore:

$$Y_i = B_0 + B_1 x_{1i} + B_2 x_{2i} + \dots + B_7 x_{7i} + e_i \dots \dots (2) \text{ (Multiple Linear Regression)}$$

$$Y'_i = B_0 + B_1 x_{1i} + B_2 x_{2i} + \dots + B_7 x_{7i} \text{ (} i = 1, 2, 3 \dots n \text{)} \dots \dots (3) \text{ (Prediction Model)}$$

In this case our regression equation $[Y' = a + B_1 x_{1i} + B_2 x_{2i} + \dots + B_8 x_{8i}]$ becomes $\beta_0 =$ predicted STUDENTS ChAT SCORES when GPTS, LP, TM, AVA, SA, FA, CCT and CCP are zero = -2.274

Where Y is predicted or explained value of the Dependent variable; B_0 is the Constant or Intercept; $B_1, B_2 \dots$ are the Slope (Beta coefficient for $x_1, x_2 \dots$ respectively) for targeted explanatory or independent variables; $x_1, x_2 \dots$ are the specific Independent variables that explain the variance in Y. The regression equation in word will be:

Students' scores in chemistry achievement test = Constant + Beta coefficient for General Professional Teaching Skills + Beta coefficient for Lesson-planning + Beta coefficient for Teaching Methods + Beta coefficient for Audio-visual Aids + Beta coefficient for Students' Activities + Beta coefficient for Formative Assessment + Beta coefficient for Course Coverage + respective errors.

Aspects of Professional Teaching of Chemistry

Multiple linear regression analyses were performed against following null hypotheses:

H₀ 1. There is no significant association between respondents' test-scores in chemistry achievement test and i) general professional teaching skills, ii) lesson-planning, iii) teaching methods, iv) audio-visual aids, v) students' classroom activities, vi) formative assessment, vii) course coverage theory, and viii) course coverage practical.

Multiple linear regression was used to predict students' achievement test scores from eight independent variables related to professional criteria of teaching of chemistry. A total of 350 students comprised the stratified sample of the study. Regression analysis revealed that above stated eight independent variables predicted respondents' scores in chemistry achievement test, $R=.649^a$, $r^2=.421$ (adjusted $r^2=.408$), $F(3, 36)=7.54$, $p<.001$.

However, the negative beta sign of unstandardized coefficients against general professional teaching skills and students' activities and higher p-values of dependent variables or predictors (having lower t -values) indicated insignificant contribution. Similarly, lesson-planning and students' formative assessment revealed insignificant statistical values ($p>.05$, and lower t -values). Those four variables could not significantly predict respondents' test-scores thus were removed one by one to get required p -value (i.e. $<.05$) (see table 2).

Table 7
Coefficients of Overall Multiple Linear Regression (All predictors)

Model	Independent variables	Unstandardized coeff.		SD coefficients	t	p -value
		B	Std. Error	Beta		
1	(Constant)	-2.274	.730		-3.115	.002
	General professional skills	-.288	.237	-.099	-1.214	.225
	Average lesson planning	.261	.251	.063	1.043	.298
	Teaching methods	1.223	.650	.158	1.881	.061
	Audio visual aids	1.206	.335	.230	3.597	.000
	Students' activities	-.143	.219	-.041	-.649	.516
	Formative assessment	.108	.186	.039	.581	.562
	Coverage chemistry theory	.718	.254	.216	2.823	.005
	Coverage chemistry practical	.617	.185	.191	3.332	.001

a. Dependent variable: Overall marks

The left out four predictors i.e. coverage of chemistry practical, teaching methods, audio-visual aids, and coverage of chemistry theory showed moderately strong positive association ($R=.645$) toward students' achievement scores and four predictor variables namely at $p<.001$. They accounted for 41.7% variability in respondents' test-scores. The value of r^2 (.417) indicates that one unit increase in above predictors accounted for 41.7% unit-increase in test-scores. The regression value was statistically significant (p value=.000^a) with higher F-value (61.6).

Among retained four variables audio-visual aids $t(345) = 4.037$, $p = .000$ occurred as a dominant predictor of respondents' test-scores with standardized positive beta value of .248. It means that one unit increase in audio-visual aids accounts for .25 points rise in standard deviation (or 130% un-standardized units rise) of respondents' test-scores. Secondly, chemistry practical (or students' lab-work) $t(345) = 3.542$, $p = .000$, stood on second place to contribute positively towards students' test-scores. It means that one unit rise in chemistry practical accounts for 20% greater score on standard deviation (with overall 64.4% un-standardized units rise). Thirdly, chemistry theory $t(345) = 3.103$, $p = .002$ predicted .198 points (standard beta value .198) increase in standard deviation of respondents' test-scores (65.9% rise in un-standardized units); whereas, teaching methods $t(345) = 2.014$, $p = .055$ predicted .113 points rise in standard deviation of students' test-scores (or 87.2 un-standardized units) rise in students' test-scores in unit standard deviation.

Demographic Variables

H₀ 02. There is no significant association between respondents' scores in chemistry achievement test and i) gender, ii) type of school (boys-only, girls-only, co-education), iii) location (rural/urban), iv) parents' income, v) parents' occupation, vi) parents' education, vii) students' home-study, viii) private tuition, ix) tuition-subjects, and x) favorite subject.

Gender, type of school, location, parents' income, occupation and education, students' home-study, after-school private tuition, tuition-subjects, and their favorite subjects were used in a standard regression analysis to predict students' scores in chemistry achievement test. The prediction model was statistically significant, $F(10, 350) = 6.389$, $p < .001$; however, accounted for only 15.9% of the variance of respondents' test-scores ($R^2 = .159$, Adjusted $R^2 = .134$). An overall moderate association ($R = .398$) was found between independent variable (test-scores) and above ten predictors. The related statistics (see table 3) put the six predictors as non-significant with poor respective values and strength, hence six variables i.e. location (rural and urban), type of school (boys-only, girls-only, and co-education), parents' education and income, and respondents' after-school tuition duration and tuition-subjects did not significantly predicted students' test-scores, therefore were discarded in analysis. Only four demographic variables significantly predicted students' test-scores.

Table 8
Coefficients of Demographic Predictors of Multiple Linear Regression

Model	Predictor	Raw coefficients		Standardized	<i>t</i>	Sig.	Pearson R
		B	Sd. Error	Beta			
1	(Constant)	-2.291	1.164		-1.967	.050	
	Gender	.726	.333	.127	2.180	.030	.082
	Type of school	-.460	.218	-.126	-2.109	.036	-.098
	Rural/urban	.553	.383	.078	1.443	.150	.166
	Income of parents	.269	.122	.132	2.200	.028	.197
	Occupation of parent	.091	.101	.048	.897	.370	.084
	Education of parent(s)	.009	.163	.003	.053	.957	.125
	Home study	.653	.221	.152	2.961	.003	.196
	After school tuition duration	.124	.367	.029	.339	.735	.121
	After school tuition subjects	.042	.228	.016	.184	.854	.128
	Favorite subjects	1.222	.282	.222	4.342	.000	.257

a. Dependent Variable: Overall Marks

Test-scores were primarily predicted by students' favorite subjects and home-study, and to a lesser extent by parents' income and gender. As can be seen in table 3, all correlations were either insignificant or of lowest value. Students' favorite subject got the relatively strongest weight among other variables' regression coefficients in the model, followed by their home-study duration, parents' income and respondents' gender.

No sizeable correlations between the predictors was found with relation to predicted test-scores. Overall all predictors showed quite low or marginal zero-order and partial correlations except the favorite subject with overall correlation of .257 (.3 rounded off) correlation which was relatively higher within weak range of correlation. Inspection of the coefficients put students' favorite subject as dominant predictor as one unit increase in it accounted for 122% units increase in respondents' test-scores. ($p < .001$, $t = 4.342$, un-standardized Beta coefficient $B = 1.22$), followed by students' home-study caused 65% of unit prediction ($p = .003$, $t = 2.961$, un-standardized $B = .653$), income of parents resulted for 26.9% of unit prediction ($p = .028$, $t = 2.20$, un-standardized $B = .269$), and students' gender catered for 72.6% unit increase with relatively lesser significance ($p = .03$, $t = 2.180$, un-standardized $B = .726$).

From the multiple linear regression analysis of the ten demographic predictors (gender, type of school, location, parents' income, occupation and education, students' home-study, after-school private tuition, tuition-subjects, and their favorite subjects) the test-scores are primarily predicted by students' favorite subjects and home-study, and to a

lesser extent by parents' income and respondents' gender. Though the prediction is statistically significant ($p < .001$), yet it is of moderate or weak level ($R=.398$) with lower prediction value i.e. 15.9% ($R^2 = .159$). From these findings, we conclude that the learners' intrinsic motivation/reinforcement accounts for better academic knowledge and understanding of the curricula and it works better than all other targeted demographic variables. However, wealthy parents and respondents' gender also seem to have significant effect on learners' test-scores. Students from wealthy parents might have better access to knowledge developing resources i.e. books, computer, internet, private tuition etc. Secondly, in our culture females do not have more opportunities to go out and spend time out of their houses due to cultural and religious influences; therefore, they generally give more time to their studies and get better marks than their male counterparts.

As mentioned earlier the existing professional teaching is either very poor or a failure one, therefore, we are of the opinion that the targeted demographic (including left-out) predictors might reveal significant association with respondents' test-scores from a sample taken from a location with better teaching and learning situation.

Independent Samples *t*-tests

Mean differences analyses (independent samples *t*-test and analysis of variance or ANOVA) were performed to find out which demographic variables and their specific sub-categories significantly affected, and accounted for students' higher chemistry test-scores. Independent samples *t*-test was used to determine the potential difference between two sub-groups of a variable i.e. gender, and location (rural/urban). It involved following null-hypotheses:

H₀03. There is no significant difference between students' chemistry test-scores and gender.

H₀04. There is no significant difference between students' chemistry test-scores and location i.e. rural and urban.

The independent samples *t*-test for first null hypothesis showed no significant difference between test-scores and respondents gender. For males ($M= 4.3$, $SD= 2.2$) and for females ($M= 4.8$, $SD= 3.5$) at $t(350) = -1.41$, $p=.16$. Therefore the researcher could not find ample evidence to reject the H₀ 1 null hypothesis (see table 4). However, the independent samples *t*-test for second null hypothesis revealed significant difference between test-scores of rural and urban strata at .05 significance level, hence H₀ 2 was rejected. Given a violation of Levene's test for homogeneity of variables, $F(1, 348)=8.98$,

$p=.003$, while not assuming homogeneous variances, a t -test was calculated and found significant difference in test-scores of both groups, $t(174) = -4.2$, $p=.000$. The result suggests that urban students ($M=4.72$, $SD=2.98$) scored significantly better in chemistry achievement test than their rural counterparts ($M=3.55$, $SD=1.77$) at $p>.001$ (see table 9).

Table 9

Independent Samples t-test (test-scores vs. gender and location)

Variable	Groups	<i>N</i>	Mean	<i>SD</i>	<i>t</i> -value	<i>p</i> -value	Result
Test-scores	Male	209	4.30	2.20	-1.41	.16	H ₀ 1
	Female	141	4.77	3.52			not
	Rural	89	3.55	1.77			Rejected
Test-scores	Urban	281	4.72	2.98	-4.22	.000	H ₀ 2 Rejected

One-way Analysis of Variance ANOVA

We used ANOVA to find out the mean differences of dependent variable (test-scores) across three or more sub-categories of an independent variable. Once, we found the significant difference between at least one of the categories in relation to others, it was further analyzed using Tukey's honest-significant-difference (HSD) for post hoc comparisons of homogeneity. We used following null hypotheses one-way ANOVA analyses to determine the mean differences of respondents' test-scores against some demographic variables:

H₀ 05. There is no significant difference between students' chemistry test-scores and education of parents (0 years of education or illiterate, 5-10yrs, 11-14yrs, 15-16yrs, 17-18yrs of ed).

H₀ 06. There is no significant difference between students' chemistry test-scores and type of school (i.e. boys-only, girls-only, and co-education).

H₀ 07. There is no significant difference between students' chemistry test-scores and their parents' income levels (unemployed or <Rs 3Kpm, <Rs10Kpm, Rs11-20Kpm, Rs21-30Kpm, Rs31-40Kpm, Rs41-50Kpm, Rs51-60Kpm, Rs61-70Kpm, Rs71-80Kpm). Kpm=1000 per month.

H₀ 08. There is no significant difference between students' chemistry test-scores and their parents occupation levels (un-employed, technical/industrial, teaching, low-grade employee, officer, own small shop/business).

H₀ 09. There is no significant difference between students' chemistry test-scores and their home-study duration (no study, 1-2hrs, 3-4hrs, 5-6hrs daily).

H₀ 10. There is no significant difference between students' chemistry test-scores and after-school tuition duration ((no tuition, 1-2hrs, 3-4hrs, 5-6hrs daily).

H₀ 11. There is no significant difference between students' chemistry test-scores and after-school tuition subjects (no tuition, languages/social sciences, natural sciences, and all subjects).

H₀ 12. There is no significant difference between students' chemistry test-scores and their favorite subjects (no subject, languages/social sciences, natural sciences, and all subjects).

The one-way ANOVA was used against eight predictors out of the ten. All findings revealed significant differences except for parents' education levels showing no significant difference on respondents' test-scores. Learners from separate education i.e. girls-only (with highest mean scores) and boys-only got better scores than their counterparts in co-education schools. Mostly, respondents from parents of higher monthly income and rank (officer-group) got better test-scores. Similarly, students spending more time on home-study and after-school tuition achieved significantly better mean scores in achievement-test than those who spent fewer hours on home-study or after-school tuition. Again, expected findings came regarding respondents' after-school tuition subjects: The students who received tuition in natural sciences (chemistry and biology subjects) scored significantly higher mean scores in achievement-test than the groups of other sub-set getting tuition in social sciences or no-tuition group. However, unexpected findings surfaced when we found that students who did not show any preference for favorite subject got better mean test-scores than those who opted for natural, social, or both sciences as their favorite subjects (Table 10 presents related statistical details of above ANOVA analyses).

Table 10

Analysis of Variance (ANOVA)

H ₀	Variables compared	Group	Sum of squares	df	Mean square	F-value	p-value	Result	Highest <i>M</i> on Tukey's HSD test
H ₀ 05	Test-scores vs. education of parents	betwn. groups within groups	64.46 2707.01	4 345	16.12 7.85	2.05	.086	Not rejected	---
H ₀ 06	Test-scores vs. type of school	betwn. groups within groups	140.13 2631.35	2 347	70.06 7.58	9.24	.000	rejected	Girls-only (<i>M</i> =5.17)

H ₀ 07	Test-scores vs. parents' income	betwn. groups within groups	211.63 2559.84	8 341	26.45 7.51	3.52	.001	rejected	Rs. 41000-50,000 (<i>M</i> =7.50)
H ₀ 08	Test-scores vs. parents' occupation	betwn. groups within groups	202.12 2569.36	5 344	40.42 7.47	5.41	.000	rejected	Officers grade 16 or above (<i>M</i> =7.43)
H ₀ 09	Test-scores vs. students' home-study	betwn. groups within groups	146.37 2625.11	3 346	48.79 7.59	6.43	.000	rejected	5-6 hours daily (<i>M</i> =7.50)
H ₀ 10	Test-scores vs. students' after-school tuition hours	betwn. groups within groups	72.22 2699.26	3 346	24.07 7.80	3.09	.027	rejected	4-5 hours daily (<i>M</i> =8.00)
H ₀ 11	Test-scores vs. students' after-school tuition subjects	betwn. groups within groups	171.22 2600.25	3 346	57.07 7.52	7.59	.000	rejected	Natural sciences (<i>M</i> =6.87)
H ₀ 12	Test-scores vs. students' favorite subjects	betwn. groups within groups	244.52 2526.95	3 346	81.51 7.30	11.16	.000	rejected	No subject (<i>M</i> =8.00)

Discussion

Findings of this study support those of Sarwar and Hussain (2010) who studied twenty-five areas of professional teaching from relatively smaller and non-representative sample (150 secondary school teachers). They found that the teachers were mostly weak in lesson planning, classroom discipline management, and content knowledge. Lesson planning remained the most burning professional issue. The top 11 burning problems stood in this sequence: lesson-planning, students' previous knowledge, flow and continuity of lesson, teaching aids, induction or introduction of lesson, students' involvement, quantity of subject matter taught, quantum of subject matter, and recapitulation and conclusion (p. 183). The findings of present study are in total agreement to above study with a couple of advantages of representative sampling technique and proper sample size. It also confirms Government of Pakistan (2007) in collaboration with UNICEF who found that about 70% of the children were reported as being punished physically.

Regarding lesson planning Gujjar, Bajwa, Shaheen, and Rehman (2011) found from 100 public secondary teachers that majority of teachers of Attok, Punjab (Pakistan) did not plan for their lessons due to lack of proper training during pre and in-service courses. The same worst situation prevails in our Sindh's context across gender and location (rural and urban) strata.

Naseer-ul-Din, Iqbal, and Rehman (2010) who from relatively smaller sample (only 18 teachers of Punjab) found that classrooms were overcrowded, theory-ridden teaching prevailed with inadequate practical work, and either the science related teaching material and resources were unavailable or not used by the science teachers. They concluded that it was the failure of professional teaching of science teachers (teaching chemistry, physics, and biology). Those findings are in complete harmony with present findings in all respects except a couple of deviations. In our case the issue of overcrowded classrooms is only at urban schools. Moreover, it disconfirms the inadequate science equipment and resources.

Limitations of the study

- Due to mere absence of related data this study could not find association of left out four variables with the respondents' test-scores i.e. students' formative assessment, students' classroom activities, lesson-planning, and general professional teaching skills. Therefore, we recommend a replicate study from a sample where the students and teachers actually involve in above areas to know whether there exists an association between respondents' test-scores and those four predictors. It also would provide insights into different demographic predictors which this study failed to find their association with test-scores.
- This study examined professional teaching of chemistry from learners' perspective; therefore, we suggest replicate studies involving teachers and head-teachers.

Conclusion and Future Prospects

RQ 1. Whether and up to what extent do the public secondary school students' test-scores relate to some aspects of professional teaching as assessed from learners' perspective?

Out of the eight predictors, the multiple regression analysis reveal that four variables i.e. coverage of chemistry practical, teaching methods, audio-visual aids, and coverage of chemistry theory significantly predict the students' test-scores at $p < .05$ ($.000^a$). The prediction is found to be moderately strong ($R = .645$) with 42% prediction surety. But the left out four predictors (students' formative assessment, $p = .56$; students' classroom activities, $p = .52$; lesson-planning, $p = .30$; and general professional teaching skills, $p = .23$) fail to significantly predict students' test-scores.

We think that it does not mean that these left-out four aspects of professional teaching are unimportant. But it reflects absence of significant data on their part. For example, no student reported formal written lesson plans on the part of their chemistry teachers; therefore, the statistical analysis software could not get evidence to correlate it to any student's test-scores! Same is the case with formative assessment, and students' classroom activities. The descriptive statistics section reveals such potential flaws regarding those variables.

On the basis of the findings and their related clues the researcher concludes that out of targeted eight aspects of teaching of chemistry the four: coverage of chemistry practical, teaching methods, audio-visual aids, and coverage of chemistry theory play crucial role in learners' knowledge and understanding of the curricula. However the left out four might have the same role but it is to be determined by replicated future studies with a sample where the professional teaching is better in terms of different aspects of students' formative assessment and classroom activities, and teachers' lesson-planning and general professional skills.

RQ 2. Whether and up to what extent do the public secondary school students' chemistry achievement test-scores relate to some of their demographical aspects as assessed from learners' perspective?

From the multiple linear regression analysis of the ten demographic predictors (gender, type of school, location, parents' income, occupation and education, students' home-study, after-school private tuition, tuition-subjects, and their favorite subjects) the test-scores are primarily predicted by students' favorite subjects and home-study, and to a lesser extent by parents' income and respondents' gender. Though the prediction is statistically significant ($p < .001$), yet it is of moderate or weak level ($R = .398$) with lower prediction value i.e. 15.9% ($R^2 = .159$). From these findings, we conclude that the learners' intrinsic motivation/reinforcement accounts for better academic knowledge and understanding of the curricula and it works better than all other targeted demographic variables. However, wealthy parents and respondents' gender also seem to have significant effect on learners' test-scores. Students from wealthy parents might have better access to knowledge developing resources i.e. books, computer, internet, private tuition etc. Secondly, in our culture females do not have more opportunities to go out and spend time out of their houses due to cultural and religious influences; therefore, they generally give more time to their studies and get better marks than their male counterparts.

As mentioned earlier the existing professional teaching is either very poor or a failure one, therefore, we are of the opinion that the targeted demographic (including left-out) predictors might reveal significant association with respondents' test-scores from a sample taken from a location with better teaching and learning situation.

RQ 3. Whether and up to what extent do the public secondary school students' chemistry achievement test-scores differ from some of their demographical aspects as assessed from learners' perspective?

Significant differences are found between students' test-scores and almost all demographic variables i.e. type of school, location, parents' income and occupation, students' home-study, after-school private tuition, tuition-subjects, and their favorite subjects. However no such differences are found with relation to gender and parents' education levels.

Since students from urban areas, separate education school (boys-only and girls-only), officer-grade parents, middle-class parents (earning between Rs 41,000 to 60,000 per month), devoting greater time (5-6 hours daily) to home-study and tuition, and after-school tuition in natural sciences, get significantly different and better mean-scores in chemistry achievement test than their other respective sub-categories. Putting it in other words, students living in rural areas, studying in co-education schools, relating to those parents having lower social status and monthly income, devoting lesser time or no time to home-study and after-school tuition, getting tuition in social sciences or no tuition significantly get lesser mean scores in their chemistry achievement test.

It certainly points out at least two things. First, learners' personal aptitude and interest (giving more time to their studies) equally competes with environmental (after-school tuition duration, and tuition in sciences) influences to bring positive learning outcomes. All this calls for providing free of cost volunteer-based tuition in collaboration with provincial government and local community (details can be seen in the section of recommendations) throughout rural and urban areas. Second, backwardness and poverty negatively affects students' knowledge and understanding of the curricula. Either students of those areas might prefer in helping their parents in making their both ends meets, thus, not be able to give proper time and consideration to their studies or lack of/poor monitoring and check and balance might have put the teachers at ease (semi-structured interviews of students confirmed teachers' absenteeism or even not taking classes). It may be overcome through strict monitoring of teaching and learning especially at rural schools.

Recommendations

We, on the basis of findings, recommend following measures to the concerned stakeholders for uplifting of teaching of chemistry at public secondary school level:

Related to professional training agencies

The tutors of B.Ed. lack in professional knowledge and skills therefore we recommend that the services from National Testing Service (NTS) or provincial Public Service Commission be hired to appoint talented, hard-working, innovative, tutors who are well-versed in the subject matter and must possess the ability and skill of translating the psychological and pedagogical content to related classroom teaching and learning.

The B.Ed. curricula should be revised to incorporate teaching and learning through active engagement of student-teachers. Moreover, the curricula should be enriched with three model lesson-plans for each psychological or pedagogical construct i.e. group-work, think-pair-share, reinforcement, demonstration, guided laboratory work, discovery, two-way lectures, discussion, and project based learning etc.

The examination system of B.Ed. also needs prompt revisions. Formal memory based examination should be diverted toward assessment of comprehension and practical skills. It could be done through inclusion of more MCQs and short-answer questions as part besides transparent practice teaching. Necessary monitory assistance should be sought from local NGOs, and officers of army/rangers during B.Ed. examinations.

Related to secondary school teachers

There should be no quota (employees' sons-quota, disabled quota, or any quota for a politician etc), and the appointment of teachers should be made through provincial public service commission.

For uplifting hard-work among teachers, a periodical (every fourth-year) proficiency test based on the curricula of B.Ed conducted by NTS. be introduced which must be qualified with a passing percentage of 70% of marks by all teachers within three attempts. Moreover, this test can be used for giving financial incentives to the teachers; for example, every time the test is open for all teachers and the top 500 teachers or so could get an allowance of Rs: 1000-2000 per month (it means previous allowance holders could only get the allowance if they still compete and fall among top 500 teachers). The revenue can be generated by deducting little amount (Rs. 50-100) from the monthly salary of existing teachers of the province.

Related to administration

A new cadre of head-teachers or administrators be introduced with higher pay-scales (than sub-ordinates) and benefits through provincial public service commission. We suggest a two-weeks pedagogical training of head-teachers regarding ensuring appropriate lesson-planning, teaching methods, students' active involvement activities, measures of formative assessment of students, and general professional teaching skills.

Once the head-teachers are trained they are required to transmit the same to their teachers and bound them to follow during routine teaching. Private firms and individuals having doctoral degree in pedagogy or teaching may be invited to design proper module/resources.

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