

Secondary science teachers' pedagogical content knowledge from content representation (CoRe) on genetics

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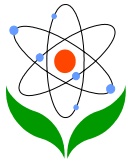
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Abstract

Pedagogical Content Knowledge (PCK) refers to certain knowledge of teacher in a particular topic, considered as an act of teaching to deal with students in a particular way. Since PCK allows a science teacher to provide quality teaching, this qualitative

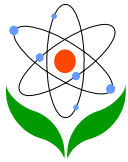


multiple case study aims to explore the nature of science teachers' PCK on the topic "Genetics" of grade eight in Bangladesh by contributing to the existing literatures on PCK. Total four teachers, one from each school, participated in this study through filling in Loughran's (2006) developed CoRe (Content Representation) template which can provide an overview of how teachers conceptualize the content of particular subject matter. Classroom observation and semi-structured interviews with those teachers were also conducted. By ensuring the trustworthiness of the research, this study presented a thematic and cross-case analysis based on the components of PCK. The results showed that, three out of four teachers belong from novice level of PCK which implies that they could not achieve the maximum PCK components even if they worked for years, yet one teacher failed to meet the criteria of novice level even. Apart from that, the participants could not meet the requirements of teaching for scientific literacy in full extent. Since this study claims to shed a light on the present condition of science teachers' PCK and their daily challenges, it would facilitate the policy makers and educationists alike in developing curriculum and textbook on "genetics" section and conducting teachers' training.

Keywords: Pedagogical Content Knowledge (PCK), Content Representation (CoRe) template, Teachers' Knowledge, Secondary Science Teachers, Bangladesh

Introduction and problem of the study

Teachers' knowledge is an important aspect to ensure the quality teaching-learning in a classroom. A significant component of this teachers' knowledge based on teaching is often called 'Pedagogical Content Knowledge' (PCK), a term coined by Shulman (1986). He identified PCK as 'the most useful forms of content representation, the most powerful analogies, illustrations, examples, and demonstration- in a word, the ways of representing and formulating the subject that makes it comprehensible for others' (Shulman, 1986, p. 9). It is not important to have almost same PCK to all teachers but there are some core components to be incorporated. PCK, deeply rooted in teacher's everyday work, is necessary for the improvement in teacher education and to assist inexperienced teachers in their progress toward intensified competence (Rollnick et. al., 2008; Rollnick, 2012; Solis, 2012). It helps to determine our knowledge in deciding what we need to know about science, to learn what to teach and to solve the problems of science teaching-learning. PCK therefore works as predictor when experienced teachers plan and carry out



instruction, which helps science education researchers, science teacher educators and teachers in professional development (Abell, 2008).

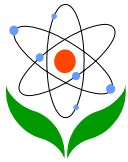
The problems that secondary science teachers face in conducting classes are widely common in global-local context which are related to the knowledge of science, goals, students, curriculum organization, instructional strategies, assessment and resource (Lee & Luft, 2008). Tapan (2010) mentioned that, the implementation of present curricula at Secondary science education in Bangladesh had not been successful as the teachers used to face difficulties regarding modern concept of textbook, activity loaded syllabus, teaching aids, assessment, examination procedure and appropriate training. Moreover, heavy teaching load often puts pressure on teachers to provide quality teaching in the classroom (Rahman, 2011). Apart from that, like many other countries Bangladeshi school teachers have lack of scientific literacy* (Lindsay, 2011; Sarkar, 2012). All these difficulties ultimately have the possibility to effect on students' learning.

Having PCK for a science teacher is thus important to ensure a quality education which can overcome the technical, academic, administrative and logistical challenges in secondary school setting. The present scenario of teachers depicts that the need further exists to understand teachers' PCK in the first stage and resolve the gaps by conducting appropriate training. Studies showed, using a Content Representation (CoRe)[†] template by Loughran (2006) allows a researcher to understand how the teachers conceptualize the content of particular subject matter. Therefore, understanding secondary science teachers' PCK from CoRe will provide a space to policy makers and educationists not only to work in science curriculum and textbooks but also for the holistic development of students' learning.

Purpose of the study and research question

* Scientific literacy has become an internationally well-recognized educational slogan, buzzword, catchphrase, and contemporary educational goal. Goodrum (2004) specified five specific attributes of scientifically literate person, who a) are interested in and understand the world about them, b) can identify and investigate questions and draw evidence based conclusions, c) are able to engage in discussions of and about science matters, d) are skeptical and questioning of claims made by others, e) can make informed decisions about the environment and their own health and wellbeing.

[†] See Appendix 1 for the details on CoRe template.



The purpose of this study is thus to explore secondary science teachers' PCK on the concept "Genetics"[‡] in Bangladesh which hopefully will contribute to the PCK literatures. To fulfill the purpose, the following Research Questions (RQs) have been possessed:

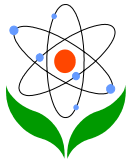
1. What is the existing nature of teachers' PCK from the Content Representation (CoRe) on "Genetics"?
2. What is the present level of PCK of those teachers?
3. Does the teachers' PCK meet the requirements of "Teaching for Scientific Literacy"?

Framework for analysis

In line with Shulman's (1986) ideas on PCK, Gess-Newsome (2013) defined PCK as 'the act of teaching a particular topic in a particular way for a particular purpose to particular students for enhanced student outcomes'. An overview of teachers PCK can be presented through a CoRe template which portrays the overall knowledge of teachers in conducting a class where the knowledge is linked to the content, students and teachers' practice (Loughran, 2006). Aydin and Boz (2012) think that all the major components of PCK are related to the themes of CoRe. CoRes offer a way in which both the issues of particular science content and specific ways of teaching can be captured and portrayed for others; which helps to have a clear idea about the nature of PCK (Loughran, Mulhall, & Berry, 2008). The big ideas of CoRes can be probed and quizzed further to understand the PCK of teachers, in which process Loughran, Berry, & Mulhall asserted that, 'the CoRe becomes a generalizable form of the participant teachers' PCK as it links the how, why and what of the content to be taught with what they agree to be important in a particular topic, including in shaping students' learning and teachers' teaching' (2006, p. 21). Thus, using CoRe template will allow us to understand the existing nature of teachers' PCK in more nuanced way.

Although the components of PCK have been varied over years, it can commonly be related to the knowledge of science, knowledge of goals, knowledge of students, knowledge of curriculum organization, knowledge of teaching, knowledge of

[‡] "Genetics" is one of the major contents in secondary science education which has been newly modified in the textbook of 2013 (NCTB, 2011).

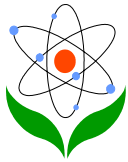


assessment and knowledge of resource (Gess-Newsome, 2013; Henze, Driel & Verloop, 2008; Grossman, 1990). However, there are some core components of PCK, like knowledge of science, goals and students. A novice teacher should have these core PCK components and expert ones possess all the other components in him (Lee & Luft, 2008). Moreover, Kind (2009) identifies three common factors that appear to contribute to the growth of PCK in early career teachers. The first factor is the possession of good subject matter knowledge; the second is classroom experience, with studies pointing to significant changes occurring in the early months and years of working as a teacher; and the third is the possession of emotional attributes like personal self-confidence and the provision of supportive working atmospheres in which collaboration is encouraged. Such characterization of novice and expert teachers on the basis of PCK components will provide us the space to highlight on individual teachers' PCK level.

Apart from that, the PCK component called knowledge of goal can be linked to the knowledge about the aim of secondary science education of Bangladesh 2013. According to the National Curriculum and Textbook Board (NCTB), the aim is to achieve scientific literacy which can be achieved through proper teaching-learning techniques (NCTB, 2011). According to Goodrum (2004), teaching for scientific literacy requires more emphasis on 12 facts like making science interesting for all, studying a few fundamental concepts, meaningful contents, guiding students in inquiry, scientific discussions, cooperative group works, open-ended activities investigating science questions, application of learning, multiple information sources, assessing learning outcomes and students' understanding, and ongoing assessment. Drawing on Goodrum's (2004) ideas will allow us to reveal if the teachers' PCK meet the requirements of "Teaching for Scientific Literacy" by providing a nuanced understanding on teachers' knowledge of goal and teaching.

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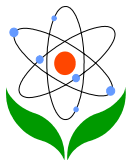
Research methods

This study is Qualitative in nature where Case study approach was chosen for in-depth exploration of the work (Creswell, 2011). Data was collected from four secondary schools of Dhaka district by using maximal variation technique since the schools were different in some characteristics. Two schools were selected based on the higher achievement and other two were selected based on the lower achievement in SSC examination 2012. That means the selection was intentional to understand the central phenomenon of teachers' PCK from different schools (Creswell, 2011). This purposeful sampling strategy was concerned according to the easy access of the researchers. One science teacher, from each school was selected using “Convenience sampling techniques” (Johnson & Christensen, 2008, p.238).

In collecting data, first of all a semi structured questionnaire familiar as CoRe Template (Loughran, Berry & Mulhall, 2008, 2006; Loughran, Mulhall & Berry, 2002) was filled by all the four teachers which further facilitated to find out RQ1 and RQ2 mainly. No time was allocated to fill in the template. After that, single observation schedule[§] was used to understand teachers' teaching approach for achieving students' scientific literacy which was designed according to Goodrum's (2004) criteria of “Teaching for Scientific Literacy” in finding out RQ3. The teachers enjoyed time-flexibility to complete the chapter “Genetics” which was thoroughly observed according to the teachers' routine. After observing classes, semi structured interviews were conducted with those teachers to have the clarification on the gaps of data collected through the other tools. This paper, focusing on four typical cases of science teacher allowed us to probe deeply the nuanced aspects of their PCK, though caution has to be exercised in drawing any broad generalization (Johnson & Christensen, 2008). Nonetheless, we have tried to maintain the trustworthiness of this study by pursuing credibility, transferability, dependability, and confirmability (Merten, 2010).

Results

[§] See Appendix 2 for the observation schedule.



The results are presented with a thematic and cross-case analysis based on the PCK components (Stake, 2006). Individual cases of all the four teachers mentioned in table 1 were studied thoroughly before presenting the analysis.

Table 1. Teachers' Profile

Teachers' pseudo name	Name of the pseudo school	Type of school	Last Educational degree
Ms. Amina	Rokeya Secondary School	Higher achievement in SSC examination 2012	M.Sc in Zoology Masters in Education
Ms. Marium	Laboratory School and College	Lower achievement in SSC examination 2012	M.Sc in Zoology
Ms. Nilufar	Modern Girls High School	Higher achievement in SSC examination 2012	M.Sc in Zoology
Mr. Kashif	Model Secondary School	Lower achievement in SSC examination 2012	M.Sc in Mathematics Masters in Education

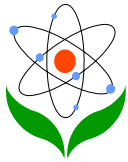
Teachers' knowledge of science

All the four teachers had good command on the topic "Genetics". In the CoRe template, they showed their clear understanding on the concept of "Genetics" under several Big ideas (Loughran, 2006). For instance, Nilufar and Amina mentioned the importance of Mitosis with proper explanation in the template. Observation data also depicted that all the four teachers were able to explain the necessary scientific details in the classroom. For example, in a certain situation of Mr. Kashif's classroom, a student asked, 'Sir, does a cell divide continuously?' The teacher replied, 'No, it has a limitation. But sometimes cells can be divided without any limitation and Papiloma virus is responsible for that. Cancer can be occurred due to this unlimited division of cells.' In spite of not belonging from biological science background Kashif's knowledge on "Genetics" was equally praiseworthy like other three teachers because all of them were really good in explaining the scientific details of "Genetics" in the interview session as well. For instance, all the teachers explained the big ideas i.e. classification of cell division, importance of cell division in interview properly.

Teachers' knowledge of goal

All the four teachers conducted their classes by considering the three learning objectives or instructional goals** of the chapter on "Genetics" which they

** The goals were based on three specific topic; a) classification of cell division, b) the growth of living being through cell

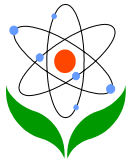


properly mentioned on the CoRe template as well. The teachers were observed to explain those before discussing any Big idea. For instance, before talking about the importance of cell division, all the teachers explained the significance of understanding this topic in their own way which led them to capture the learners' attention. In interviews, all the teachers expressed that discussing goals of a particular chapter gave direction to their lessons. According to Amina, students have so many curiosities in this adolescence period of their lives; this chapter helps the students to meet their curiosities on growth of body and birth of students...the students will be able to know about formation of body parts after this chapter.

Although the teachers had enough idea about the instructional goals, they were not properly aware about the broader goal on achieving scientific literacy mentioned in the curriculum (NCTB, 2011). Observation data depicted the inefficiency of teachers in teaching for scientific literacy where they could not meet the requirements in full extent. For example, Kashif met only 6 facts (out of 12) of teaching for scientific literacy. Three out of four teachers told in the interview that they were not familiar with the broader goal of secondary science education and not even with the term "Scientific Literacy" yet they were interested in achieving instructional goals of the chapter.

Teachers' knowledge of students' learning

Three out of four teachers had showed basic knowledge of students' learning. Data from CoRe template showed that the teachers acquired the knowledge of students through classroom experience, especially by questioning. This data is consistent with classroom observation data where the teachers were found to be involved in doing different activities and communicating with students to understand the nature of misconceptions and prior knowledge the students actually possessed. The teachers were also observed to act spontaneously by understanding students' capability and interest. For example, in need of a group work in conducting a lesson "Mitosis", teacher Nilufar preferred small groups of three students by knowing the potentiality of each individuals. She stated, 'I often let the students to draw pictures on the board. Sometimes give them the scope to make any chart or model, pair work, group work and debates which allow me to know them better'. Interview sessions also revealed that the teachers could comprehend students' level of interest and understanding on a particular topic by observing their facial expression and ways of response.



In contrary, another teacher, Marium, was observed to have lack of enthusiasm to understand students' learning which probably made her less active in the class. While asked about her engagement in knowing her students, she stated, 'I try but have nothing to do if the students do not understand! Now I do not bother so much about them since I am extremely disturbed with their inattentive nature in the classroom'. She thus made responsible to the students for gradually losing her interest regarding their learning.

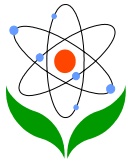
Teachers' knowledge of curriculum

A tendency to just follow the textbook by not even looking into the curriculum was found from the teachers. Data revealed the teachers did not read the latest national curriculum published on 2011 which is why they could not fill in the section on knowledge of curriculum on the CoRe. Due to such gap of knowledge they could not follow the instructions given in the curriculum. For example, it was instructed in the curriculum to split the chapter on "Genetics" into nine periods (NCTB, 2011), whereas all the teachers completed the chapter within four periods. In interviews, all the four teachers admitted their limitations in curriculum knowledge. Amina stated, 'I have not seen the new curriculum yet and could not get the chance to know the teaching-learning instructions related to the topic Genetics'. The teachers therefore followed their own strategies to conduct the classes.

Teachers' knowledge of teaching "Genetics"

Three out of four teachers believed on applying traditional teaching approach and were not able to use appropriate teaching-learning methods properly. They mentioned in the CoRe template that, since they had no enough time to take preparation for other teaching-learning methods, they usually relied on lecture method to conduct the classes on Genetics. The teachers were also observed to not being comfortable in applying various effective teaching strategies for science classes, though Kashif and Nilufar tried to use demonstration method. On the other hand, Amina admitted the reasons behind choosing lecture method in her interview, she affirmed:

I actually cannot take the class in other methods rather using lecture method, because if I want to use demonstration or other methods than I have to take preparation before starting the class which is not possible due to my work load and administrative tasks.



The teachers had the tendency to provide lecture even while demonstrating anything rather inspiring the students to ask questions or discuss among themselves. Overall, data indicated that heavy work load deprived the teachers to enrich this category of knowledge. It is noteworthy that, all of the teachers except Marium were concern about giving motivation before starting the class, repeating previous lesson, giving feedback to students, using real life examples and focusing on body language.

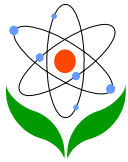
Teachers' knowledge of assessment

All the four teachers were not clear about 'what' and 'how' to assess the students. In the CoRe template the teachers expressed that they preferred asking random questions to assess the learners. This is consistent with the observed data where the teachers were found to ask knowledge based questions avoiding any sorts of written tasks i.e. multiple choice questions, matching etc. in the classroom. For instance, Amina asked 'What is cell division? How many types of cell division are there?' Such questions can be answered by recalling and the teachers possessed the tendency to ask this type of questions rather focusing on comprehensive and analytical questioning. In interviews, three out of four teachers expressed their interest on conducting group work and written task during formative assessment but due to time limitations they could not arrange those. Consequently, exercising knowledge based questions for assessing students became more preferable among the teachers since it demands lesser time comparatively.

Teachers' knowledge of teaching aids

The teachers basically had the tendency to go with traditional teaching aids like chalk, board and textbook due to time, money and infrastructural constraints. In the CoRe template, some specific teaching aids i.e. model of cell division, poster for drawing, relevant photographs, charts etc were mentioned by the teachers which they thought that should be used in conducting classes on "Genetics" for the better understanding of students. But it was observed that only Kashif and Nilufar used some of the mentioned teaching aids whereas rest of the two teachers used chalk, board and textbook only to conduct the classes. Nilufar noted that,

I try to use some colorful pictures and charts to explain the topics in the classroom. It helps saving my time in the class. I often asked the students to made such charts and models before starting the class.



Only Kashif was observed to use some animated video clips in the classroom. He affirmed in the interview, 'I wanted to ensure sustainable knowledge of students, which is why I used video clips. I believe, it helps the students to understand the abstract ideas of genetics properly.' Amina and Nilufar also shared their interest to demonstrate some video materials to students but due to financial problems and infrastructure of the school they could not do so.

Discussions

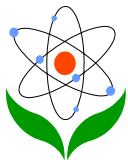
The discussion is presented under the RQs which will allow the readers to understand the zest of the findings through critically engaging with different literatures.

RQ 1: What is the existing nature of teachers PCK from the Content Representation (CoRe) on "Genetics"?

By drawing on Shulman's (1986) concept on PCK, this study revealed teachers' involvement in representing contents on "Genetics". Loughran's (2006) CoRe template allowed them to provide an overview of how they conduct a class with their existing knowledge. Here the CoRes facilitated to link teachers' PCK and its importance in shaping students' learning which was also found in Loughran, Berry and Mulhall's (2006) work. This paper, however, does not claim to capture all components of PCK and maximum studies could not capture that too (Aydin & Boz, 2012). The themes derived from CoRe are similar to the major components of PCK (Grossman, 1990; Lee & Luft, 2008)..

Teachers' knowledge of science

The result showed teachers had enough knowledge on the science topic "Genetics" which facilitated them to provide appropriate explanation on the concepts in the classroom even if one of them had mathematics background. This finding is consistent with the ideas of contention by Tapan (2010), that teachers' appropriate scientific explanation of an abstract science topic is crucial to ensure quality teaching-learning process. By drawing on Loughran, Mulhall, & Berry's (2008) idea on using CoRe, this paper revealed that the teachers gathered proper knowledge on "Genetics" by specifically focusing on the big ideas mentioned in result section. Similar results were found by Loughran, Mulhall, & Berry (2008;



2002) who depicted that CoRe allowed science teachers to bring out their knowledge on specific topic under several big ideas.

Teachers' knowledge of goal

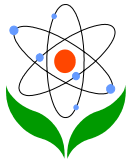
Although the teachers were not aware about the broader goals of science education in Bangladesh, they knew about the learning objectives of the topic "Genetics" which can also be called as instructional goals according to Loughran (2006). Here our ideas are consistent with Aydin and Boz (2012), who thought that the learning outcomes provided in the textbook helps the teachers to plan their lessons which ultimately leads to achieve the instructional goals of a specific science content. Drawing on Gess-Newsome's (2013) concept on PCK, such knowledge of teachers can particularly enhances students' outcome.

Teachers' knowledge of students

The results revealed, three out of four teachers had basic knowledge of students' learning which they usually understood through asking questions in the classroom mainly. Crouch & Mazur (2001) also found that, questioning helps a lot to understand students' conception in science classes. Apart from questioning, one of the teachers mentioned that students' body language or facial expression can facilitate to understand their idea on a particular content which is also consistent with Crouch & Mazur (2001). According to Loughran, Berry and Mulhall (2006), such knowledge of students allowed a science teacher to shape students' learning in a positive manner.

Teachers' knowledge of curriculum

The study identified that the teachers were not properly aware of the latest national curriculum of 2013. Similar results were also found by Sadat (2001) who worked with 1996's national curriculum. Despite of the fact that, the teachers did not get the curriculum in their hand, they knew some of its information i.e. number distribution, time management and examination process from the head of the schools. But the curriculum is consisted with more technical aspects that a science teacher should know, for example preparing lesson plan, teaching methods and its application, values for students' development, etc. (NCTB, 2011). Here our argument is consistent with Tapan (2010) who emphasized on ensuring the availability of curriculum in the schools, which will help the teachers to up-to-date their knowledge of curriculum.



Teachers' knowledge of teaching "Genetics"

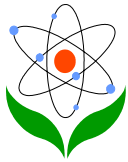
The findings revealed teachers' preference in using lecture method, though the latest curriculum instructed to follow inquiry method in a priority basis to conduct science classes on "Genetics" (NCTB, 2011). In the context of Bangladesh, different studies indicated that majority of the teachers from secondary level rely more on lecture methods than other methods (Sadat, 2001; Gomes, 2007). Anne & Coll (2010) found the similar result in different context. Teachers reported that heavy work load for classes, administrative works, time limitation, political unrest of the country, huge syllabus, lack of materials were the reasons of not applying other methods excluding lecture method which is consistent with Sadat (2001). Overall, the majority of the teachers (3 out of 4) did not try to follow the "Learner centered teaching learning" (NCTB, 2011, p. 13) approach that has been suggested in the curriculum of 2013, therefore they could not take a step towards quality education through their teaching knowledge.

Teachers' Knowledge of Assessment

This research showed that, the teachers mainly asked questions to assess the students formatively which only could assess their recalling power, rather analytical skills. McNeil (2010) found that exercising knowledge based questions highly promote memorization skill which can often not ensure the actual learning of students. The educationists therefore usually suggest practicing questioning not only from knowledge base but also from comprehension level and higher order learning level of students (Tapan, 2010; Walsh, 2010). National curriculum, on the other hand, instructed to assess through activity based class work and home works (NCTB, 2011). The large number of students in the classroom was observed as one of the reasons which hindered the teachers to even assess the homework. Consequently, as Tapan (2010) asserted, such lack of teachers' knowledge could be responsible for not meeting the requirements of quality education. To ensure quality education, McNeil (2010) therefore suggested teachers to assess students' higher order skills by letting the students to do interactive activities inside classrooms.

Teachers' Knowledge of teaching aids

Majority of the teachers (3 out of 4) showed the tendency to not use appropriate teaching aids to conduct lessons on "Genetics". Such lack of interest to use teaching aids is not very uncommon among the secondary level teachers in



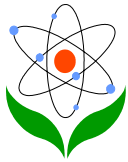
Bangladesh context (Sadat, 2001). Maximum teachers here avoid using effective teaching aids because “there is a general shortage of science equipment in secondary schools” (Tapan, 2010, p.23). Although the latest science curriculum suggested to use locally made low cost improvised teaching aids (NCTB, 2011), it was tough for the teachers to arrange those teaching aids for their heavy workloads. Such heavy workloads often work as barrier to ensure quality teaching according to Rahman (2011).

On the other hand, only one teacher in this study was eager to use teaching aids like animated video clips on “Genetics” which helped him to draw students’ attention. Adeyanju (2003) found that using video clips as teaching aids can increase students’ participation in the classroom. However, financial insolvency and poor infrastructure of the school were found as the major reasons why majority of the teachers avoid using appropriate teaching aids which is consistent with Tapan (2010). Nonetheless, proper knowledge of teaching aids could allow the teachers to meet the existing challenges which could ultimately help students to achieve scientific process skills and problem solving skills (NCTB, 2011).

RQ 2: What is the present level of PCK of those teachers?

Results revealed that majority of the teachers (3 out of 4) had knowledge regarding science content “Genetics”, instructional goals of the chapter and students learning. They can therefore be placed under novice level by drawing on Lee & Luft’s (2008) concept on teachers’ PCK level. No teacher in this study was found to fulfill the requirements of being an expert teacher which demands to have knowledge beyond the core components of PCK (Lee & Luft, 2008). Following Lee & Luft’s (2008) concept on teachers’ PCK level, one of the teachers in this study could not even meet the criteria of having novice level PCK as she did not have the knowledge of students’ learning. The teachers PCK level was also identified by the classroom experiences that they possessed to bring significant changes in their teaching style which is consistent with Kind’s (2009) notion of teachers’ PCK growth. She talked about the possession of emotional attributes as one of the factors that contribute to teachers’ PCK growth, the argument here is consistent with her by highlighting on the fact that emotional attributes like self-confidence was not found among majority of the teachers which indicated their poor growth of PCK.

RQ 3: Does the teachers’ PCK meet the requirements of “Teaching for



Scientific Literacy”?

Though secondary science education of Bangladesh aims to produce scientific literate persons (NCTB, 2011), the participant teachers of this study did not focus on teaching for scientific literacy. They did not emphasize on the aspects like scientific discussion, students' inquiry, assessing students' investigation skills etc. which were suggested by Goodrum (2004) to ensure teaching for scientific literacy. Goodrum's (2004) observation facts to teach for scientific literacy argue for engaging students with science everyday which cover major PCK components suggested by Lee & Luft (2008). Walsh (2010) found that teachers' such lack of knowledge and effort in the classroom hamper students' development process to be a scientific literate person. Sarkar (2012) found identical result in the context of Bangladesh which can yet vary in other country context. For example, Program for International Student Assessment (PISA) observed that the traditional approach of teaching in Australia often may not vary students' achievement (McGrew, 2010). However, teachers' PCK could increase the possibility to provide students with the complex idea of scientific literacy (Lindsay, 2011; Appleton, 2006).

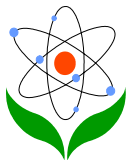
Implications and Conclusion

Implications

The implication of the study was designed from the perspective of teachers, educators, curriculum specialist, science researchers and classroom practice.

Implication for Secondary science teachers and researchers

This study would contribute to develop teaching expertise by making the teachers aware about the knowledge that they should have to conduct secondary science classes. The results may facilitate teachers to prepare lesson plan on “Genetics” by considering the challenges of secondary science teachers that this study highlights. Teachers and researchers may also be able to think of other possible solutions of those problems which may lead them to encourage in professional learning in future. The discussion of this study would provide a space to comprehend teachers' own PCK level. Apart from that, the findings may encourage the science and PCK researchers in working for the betterment of students' achievement and science teachers' development in Bangladesh. The transferability of this study would allow



other researchers to follow the similar methods in their own work (Lincoln & Guba, 1985).

Implication for curriculum specialist, educators and policy makers for secondary level

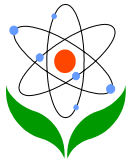
The curriculum specialist, educators and policy makers would find this study helpful while developing the “Genetics” section on the curriculum and textbook since the findings illustrated the present condition of secondary science teachers’ knowledge on this particular topic. As this research sheds light on the fact that the teachers had lack of knowledge on the pedagogical aspects like teaching and assessment, it would allow the policy makers to take initiative in professional developmental programs to minimize the problems.

Implication for classroom practice

Drawing on Goodrum’s (2004) concept on requirements of teaching for scientific literacy, this study would allow the readers to ponder upon the aspects that we should emphasize in classroom practices. For instance, a teacher needs to encourage group works and scientific discussion where the students will participate spontaneously. By engaging students actively on the basis of their experience and interest in the teaching-learning process could lead them to become scientific literate person gradually. [

Concluding remarks

This study started with the tension of current problems, practice and knowledge of science teachers in Bangladesh. We realized that using CoRe would allow us to understand the present condition of secondary science teachers’ PCK. Taking this study as a challenge, we collected data from different schools where we saw teachers to become confused in filling up the CoRe template which they never filled in before. But they came up with highlighting their knowledge on conducting a science class on “Genetics” which provides us with the space to analyze that three out of four teachers’ PCK level is novice whereas another one could not even met the criteria of novice level. Apart from the fact that the teachers’ experiences in conducting science classes did not reveal their expert level PCK, they were not found to teach for scientific literacy as well. Such findings bear the significance to conduct research and work for improving science teachers’ PCK in global-local



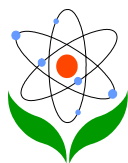
context, unless it would not only effect on students' achievement in becoming scientific literate persons but also on quality education.

Acknowledgement

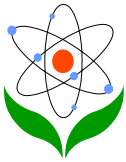
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