The Effects of Collaboration in the Constructivist Web-Based Learning Environment of an Undergraduate Physics Course

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Abstract

The effects of the student-facilitator and student-peer collaboration in the constructivist Web-based learning environment of an undergraduate Physics course are reported. A specially designed constructivist Web-based learning environment was constructed based on the Black & McClintock model with the topic of X-Ray and Photoelectric Effects that conformed to the course curriculum of ZCT 104 - Modern Physics offered by the School of Physics, Universiti Sains Malaysia (USM). A total of 81 students was exposed to the constructed Web-based learning environment and involved in the synchronous collaboration as required by the constructivist learning principles. A specially designed questionnaire was administered to the students after the exposure. The analysis of data revealed that the student-facilitator collaboration had resulted in a positive educational output, and highlighted the importance of scaffolding by the facilitator that provided the students with motivation, reduced the task complexity and provided a structure to the learning mechanism. The student-peer collaboration resulted in the enhancement of the task performance by the students, reflected in the greater depth of their contribution and an improvement in the quality of learning through active participation. The student-peer collaboration also fostered dialogue, good communication skills and team work among the learners.

Abstrak

Artikel ini melaporkan kesan kolaborasi antara pelajar-fasilitator dan pelajar-rakan dalam persekitaran pembelajaran konstruktivisme berasaskan Web untuk kursus Fizik pra siswazah. Persekitaran pembelajaran konstruktivisme yang khusus dibina berasaskan model Black & McClintock untuk tajuk Sinar-X dan Kesan Fotoelektrik yang bersesuain dengan kurikulum kursus ZCT 104 - Fizik Moden yang ditawarkan oleh Pusat Pengajian Sains Fizik, Univerisiti Sains Malaysia (USM). Sejumlah 81 orang pelajar didedahkan kepada pesekitaran pembelajaran yang dibina yang melibatkan kolaborasi sinkronous seperti yang dikehendaki oleh prinsip pembelajaran konstruktivisme. Analisis data menunjukkan kolaborasi pelajar-fasilitator menghasilkan output pembelajaran yang positif, dan memberikan perhatian kepada kepentingan sokongan fasilitator yang memberikan pelajar motovasi, mengurangkan kesukaran kerja dan memberikan struktur kepada mekanisma pembelajaran. Kolaborasi pelajar-rakan menghasilkan peningkatan kepada prestasi kerja pelajar, mencerminkan kedalaman yang lebih terhadap sumbangan mereka dan memperbaiki kualiti pembelajaran melalui penglibatan yang aktif. Kolaborasi pelajar-rakan juga menggalakan perbincangan, kemahiran komunikasi yang baik dan kerja berkumpulan di kalangan pelajar.

Introduction

The constructivist learning environment may be defined as a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities (Wilson, 1996). The learning environment must contain at least a learner and the "setting" or "space" wherein the learner acts, using tools or devices, collecting and interpreting information and interacting with others.

Such an environment conforms to the constructivist approach of learning which emphasises that learners do not receive segments of knowledge and store them in their heads. Instead, they absorb information from the world and then construct their own view of that knowledge domain, i.e., all knowledge is stored and accessed by an individual via experiences associated with knowledge in a particular domain (Jonassen, 1999). The characteristics of the constructivist learning environment as described by Carr et al., (1998) contain the following functions or components: learners are active, multiple perspectives are valued and necessary, learning should support collaboration not competition, focuses control at the learner's level and provides authentic, real-world learning experiences.

The collaboration involving student-facilitator and student-peers thus embodies the inherent characteristics of the constructivist learning environment and plays a vital role in the construction of knowledge and understanding through articulation, negotiation and reflections on ideas. Collaboration may be defined as learning in a group that involves an instructional method which encourages students to work in the learning and knowledge-building communities, exploring each other's skills while providing social support and modelling and observing the contribution of each member on a defined academic task (Jonassen, 1995). It is fundamentally different from the traditional direct-transfer or one-way knowledge transmission model in which the instructor is the only source of knowledge or skills (Edelson et al., 1996). Activities such as role playing exercises, group projects, debates, simulation, the collaborative composition of essays, research plans that involve sharing and the presentation of knowledge, expertise and skills are some examples of collaborative learning. The collaborative learning pedagogy shifts the focus from the teacher as a content expert to the role of facilitator and peer relationships play a significant role in the students' educational success (McLoughlin & Luca, 2002). When working with peers and facilitators instead of being alone, anxiety and uncertainty are reduced as learners find their way through complex or new tasks. In general, the reduction of anxiety and uncertainty tends to increase student motivation and satisfaction with the learning process (Harasim et al., 1997).

Collaboration in Web technology commonly uses asynchronous e-mails, Web bulletin board postings or synchronous chat facilities. Each of these is only a tool for communi-

cation. Since communication is necessary for collaboration, the use of these Web-based communication tools suggests that Web collaboration can be easily accomplished. Using such tools, the learner actively constructs knowledge by formulating ideas into words, and these ideas are built upon the reactions and response of others (Alvi, 1994). In other words, learning takes place in an active and interactive environment.

There have been a number of studies on the effect of collaboration in the Web-based constructivist learning environment (Edelson et al., 1996; Agostinho et al., 1997; Whittle et al., 2000; Huang, 2002; McLoughlin & Luca, 2002). Most studies agreed that learning has to be deliberately scaffolded or assisted so that novices develop competence. Scaffolding can be achieved by offering social, cognitive and affective assistance in the form of help, on-line resources, heuristics and peer support. On the other hand, the collaboration among learners encourages them to develop multiple perspectives regarding their task and promotes articulation of different and contrasting views, resulting in a rich and robust knowledge base.

The aims of this study are to look at how students perceive the effects of the collaboration in the Web-based constructivist learning environment of an undergraduate Physics course. The Web-based constructivist learning environment was specially designed and constructed for this study. The findings of this study will provide information that can lead to an understanding of the effects of the collaboration towards the learning process in the constructivist Web-based learning environment.

Methodology

A constructivist Web-based learning environment was specially designed and developed for the purpose of this study. The design approach was adapted from the Interpretation Construction Design Model proposed by Black & McClintock (1996). This model consists of seven principles, namely:

- **Observation**: Students make observations of authentic artifacts anchored in authentic situations.
- **Interpretation Construction**: Students construct interpretations of observation and construct arguments for the validity of their interpretations.
- **Contextualisation**: Students access background and contextual materials of various typess to aid interpretation and argumentation.
- **Cognitive Apprenticeship**: Students serve as apprentices to teachers to master observation, interpretation and contextualisation.
- **Collaboration**: Students collaborate in observations, interpretation and contextualisation.
- **Multiple Interpretations**: Students gain cognitive flexibility by being exposed to multiple interpretations.
- **Multiple Manifestations**: Students gain transferability by seeing multiple manifestations of the same interpretation.

The title of the Web-based learning environment constructed was "X-Ray and Photoelectric Effects" and the content incorporated into the Web was in accordance to the ZCT 104 - Modern Physics course curriculum offered to the first year science students enrolled in the School of Physics, Universiti Sains Malaysia (USM). From a total of 460 registered students in the course, 81 students were selected randomly for the study.

The students were first divided into smaller groups of about 20-30 students and each group was exposed for a period of 1 1/2 hours to the constructivist Web-based learning environment. The constructivist approach of learning required these students to inde-pendently seeking new information and knowledge regarding a defined educational task related to the topic of X-Ray and Photoelectric effects: The construction of new knowledge was achieved via the numerous Web links of related resources provided to them. With the help of the resources, they subsequently engaged themselves in a synchronous collaboration with their peers and the facilitator to achieve the goal of formulating a suitable group-based solution to the defined academic task. The first page of the Web provided information on the learning processes involved and elaborated on the role to be played by them as well as the role to be played by the facilitator. All the students were new to this learning environment and information and instructions per-taining to the role to be played were imperative for the successful outcome of the learning process. The introductory page of the Web is shown in Figure 1.
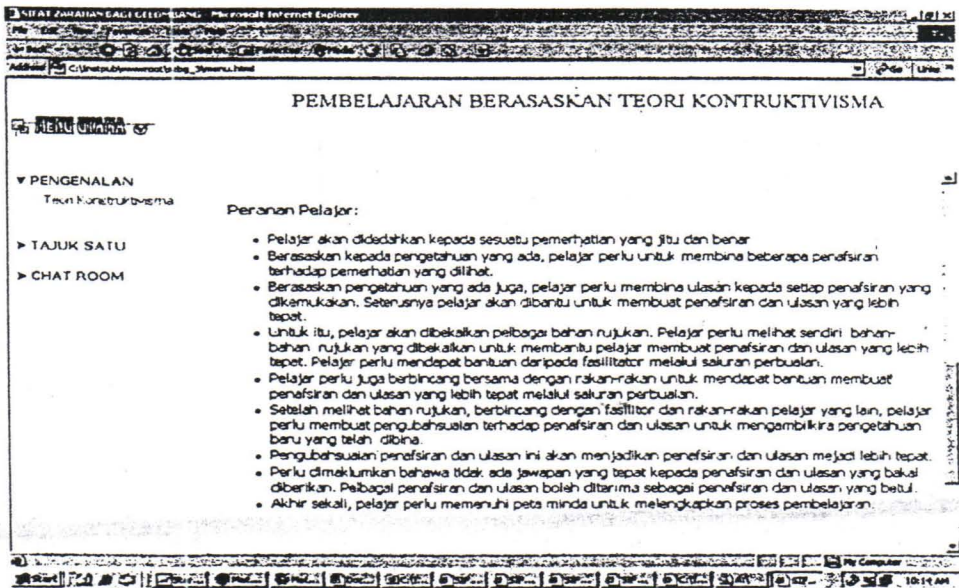

Figure 1   The Introductory page of the Web-based constructivist learning environment

The collaborative aspect of the Web-based learning environment designed for this study involved only synchronous collaboration between the students and their facilitator and among the students themselves with their peers. Apart from playing the role of a coach, the facilitator also encouraged and directed the students to be actively involved and work cooperatively in the group so that each student could make his/her own interpretation as well as obtain a sense of other perspectives.

At the end of the treatment, a questionnaire was administered to the students. This questionnaire was specially designed to elicit the respondents' perceptions towards the effects of the learning processes that they felt during the treatment. The questionnaire developed for this study consisted of 64 statements and each statement was accompa-

nied by a 4-point Likert scale ranging from 1-4, with 1 denoting the most disagreeable and 4 denoting the most agreeable. The statements were categorised under the dimensions of Content Material, Delivery of Content Material, Collaboration with Facilitator, Collaboration with Peers, Resources, and Learning Evaluation. The Chronbach's alpha coefficient reliability was calculated for each of the dimensions and they indicated a high internal consistency as shown in Table 1. For the purpose of the study reported in this article, only the statements related to the Collaboration with Facilitator and Collaboration with Peers were reported, with the dimensions containing 8 and 9 statements respectively.

Table 1   Validation of the questionnaire

Dimension	Number of items	Chronbach's alpha coefficient
Content material	7	0.8645
Delivery of course material	22	0.9166
Collaboration with facilitator	8	0.9148
Collaboration with peers	9	0.9073
Resources	7	0.8992
Learning evaluation	11	0.9550
Total	64	0.9260

The analysis of the data involved extracting the means of each of the statements with the means of 2.500 representing the equilibrium point. The means greater than 3.000 reflects the degree of the respondents' agreement with the statements put forward while means with values less than 2.500 reflected the degree of the respondents' disagreement with the statements put forward to them.

Results and Discussion

The impact of the collaborative process between student and facilitator in the constructivist Web-based learning is shown in Table 2. In general, all the statements registered means higher than 2.500, an indication of a high degree of agreement among the respondent towards the statements put forward to them.

It is clear that the respondents perceived that they had gained positive educational output from the collaboration with the facilitator ($\bar{x}$ = 3.049). This was made possible through the quality interaction with the facilitator ($\bar{x}$ = 3.225) that had taken place and an indication that the facilitator had provided them with professional guidance for the construction of their new knowledge ($\bar{x}$ = 2.975). McLoughlin & Luca (2002) stressed the importance of scaffolding that provides assistance to a learner from a facilitator who helps him/her to perform a task that would normally not be possible to accomplish through independent and individual work. The scaffolding also motivates the learner, reduces frustration and task complexity and provides structure.

The results also show that the facilitator responded promptly to any query put forward by him ($\bar{x}$ = 3.071) and played an effective role in encouraging the participation of the students into the group discussion ($\bar{x}$ = 3.037). The students also found that the col-

laborative learning was easier with the help and guidance of the facilitator ($\bar{x} = 3.135$) and such interaction established effective learning ($\bar{x} = 3.074$). Whittle et al., (2000) reported that online collaboration with a facilitator provides opportunity for prompt feedback, stimulates a flow of dialogue and online debates and at the same time, supports peer collaboration and group dynamics as well as establishes a sense of community. All these make the learning realistic and relevant and, given ownership over this learning and a voice, allow the students to take control of their learning (Whittle et al., 2000).

Table 2   The effect of student - facilitator collaboration

No.	Statement	N	Mean	Std
1.	Interaction with the facilitator established effective learning	81	3.074	0.685
2.	It was easier to learn with the help of the facilitator	80	3.135	0.670
3.	The facilitator helped in my learning	81	3.049	0.610
4.	The facilitator encouraged my participation	80	3.037	0.736
5.	It was easy to contact the facilitator	80	2.925	0.735
6.	The facilitator responded promptly to my query	81	3.071	0.565
7.	The facilitator provided guidance to the construction of new knowledge	80	2.975	0.674
8.	I experienced quality interaction with the facilitator in terms of learning	80	3.225	0.573

The effects of student-peer collaboration in terms of educational processes are shown in Table 3. Again, as in Table 2, generally all statements registered mean values greater than 2.500, indicating the high degree of agreement among the students towards the statements put forward to them.

In terms of educational output, the student-peer collaboration in the Web-based constructivist learning environment had resulted in a positive learning outcome ($\bar{x} = 3.012$) through the link-up of different ideas raised in discussions ($\bar{x} = 3.296$), the sharing of knowledge ($\bar{x} = 3.111$) among the collaborators as well as the existence of quality interaction ($\bar{x} = 3.086$) in the discussions. Hitz et al., (1999) revealed that the motivation of students participating in an online collaborative assignment increases, and thus the amount of active participation and the quality of learning also increase. The collaboration enhances task performance due to the nature of the synchronous environment in which the participants can reflect on their contribution in more depth and without hesitation (Hitz et al., 1999). Hitz et al., (1999) also found that students engaging in individual online conditions reported lower levels of motivation than students working together in groups online. Putting individuals online to interact with course materials is not as effective as the interaction existing in the traditional classroom. However, using collaborative learning approaches can make online learning as least as effective as traditional classroom teaching (Hitz et al., 1999).

Where the aspect of communication is concerned, it is apparent that the collaboration has positively contributed to the enhancement of the communication skills ($\bar{x} = 3.135$)

of the students; these students valued the opinion of other students ($\overline{x}$ =3.160) and at the same time, they too became confident enough to raise their own ideas ($\overline{x}$ =3.135). They also realised that importance of cooperating with others in the construction of new knowledge ($\overline{x}$ =3.123). Whittle et al. (2000) reported that student-peer collaboration resulted in the development of communication skills and critical thinking, leading to the discovery of own leadership skills.

Table 3   The effects of student-peer collaboration

No.	Statement	N	Mean	Std
1.	It helped me greatly in my learning by enabling me to interact with other students.	81	3.012	0.733
2.	I have a chance to share knowledge with other students.	81	3.111	0.689
3.	I have a chance to cooperate with other students.	81	3.123	0.696
4.	Learning by interacting with other students enhanced my confidence.	80	3.112	0.636
5.	I experienced quality interaction with the other students in terms of learning.	81	3.086	0.710
6.	The interaction enhanced my communication skills.	80	3.135	0.670
7.	The interaction enhanced my confidence to raise my own ideas.	81	3.135	0.627
8.	The interaction enabled me to value the opinion of other students.	81	3.160	0.580
9.	I managed to link up the different ideas raised in the interaction.	81	3.296	0.600

Summary

This study revealed that the student-facilitator and student-peer constructivist approach promoted by the Web-based learning environment results in many positive aspects of the educational outcomes. The synchronous student-facilitator collaboration is perceived to be the effective pedagogy that can result in the enhancement of the learning quality through the engagement of group tasks and the scaffolding provided by the facilitator. The student-peer collaboration enables the students to link up different ideas, share knowledge and induces motivation that contributes to positive learning outcomes. The student-peer collaboration also fosters active participation, the development of good communication skills and team work among learners.

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