The Features and Potential of Interactive Response System

Tzu-Chien Liu
Graduate Institute of Learning & Instruction
National Central University, ChungLi, 320, Taiwan
ltc@cc.ncu.edu.tw

Jen-Kai Liang, Hsue-Yie Wang, Tak-Wai Chan
Department of Computer Science & Information Engineering
National Central University, ChungLi, 320, Taiwan.
{steven, husyie, chan}@src.ncu.edu.tw

Abstract: Integrating Interactive Response System (IRS) with a classroom computer is an inexpensive and promising means to overcoming or alleviating obstacles of in-class teacher-student and peer interactions. Unfortunately, such potential applications are often neglected. Accordingly, this study identifies IRS's features, investigates the merits and limitations of applying existing IRSs to instruction and learning, and further interprets how IRS's existing features can be elaborated and generates more useful features for instructional application based on three finished research: 1. developing a more powerful IRS, called EduClick II, to support various types of classroom activities and interactions, 2. expanding IRS to a network-supported environment to facilitate teachers' developing and sharing of pre-authored IRS-based materials, students' review of the materials and their in-class response on the IRS after class, and parents' understanding of their child's performance in using IRS, and 3. expanding IRS to other advanced devices, which could possess IRS's existing features.

Introduction

Although successful teaching typically involves interaction (Sharples, 2000), the conventional classroom confronts several limitations, such as time limits and the uneven opportunities for the students to communicate with their teacher. Good & Brophy (1995) noted that the time for which a teacher is in contact with students is very limited, regardless of whether the teacher is teaching the entire class, has divided the class into several groups, or has assigned individual students to individual tasks. Additionally, students' opportunities to interact with their teacher are often determined by their seating arrangement (Adams & Biddle, 1970; Alharjri, 1981) or achievements (Rowe, 1969; Brophy, & Good, 1970).

Even though computers have been brought into classrooms, they do not help alleviate the limitations mentioned above (Huang et al., 2001) because fewer changes have been made to typical classrooms over the last decade. Chan (2002) indicated that a serious problem of deploying information technology in K12 in Singapore, Hong Kong and Taiwan is the low accessibility of computers by students in schools. Accordingly, Norris, Soloway, and Sullivan (2002) asserted that personal computers are not really personal to students because nowadays not every student can afford to own a computer. In Taiwan, a computer with a television or video projector has gradually become the primary equipment in an ordinary classroom (MOECC, 2003). A teacher can use the classroom computer to present multimedia content to students during a class. Such a classroom computer supports only one-way transmission, rather than two-way interaction between a teacher and students.

As an increasing number of funding are invested to bring computers into classrooms, parents, policymakers and educators must be able to determine how technology can be used most effectively to improve students' learning (Roschelle et al., 2000). Since simply bringing a computer into a classroom cannot remove limitations on interaction, relevant accessories are needed to build an appropriate interactive environment. The accessories must have the following characteristics. Firstly, every classroom member can use the accessories easily to react, transmit and show

her/his responses. Secondly, the accessories must immediately receive and calculate all students' responses to help the teacher make good decisions during instruction. Thirdly, the accessories must support and extend ordinary classroom activities, such that the teacher and students do not need to alter completely their instructing and learning habits. Finally, the accessories must be cheap enough to be affordable by most teachers and students' parents.

The Interactive Response System (IRS) may be the best choice to meet the demands stated above. IRS is a technology-enabled learning environment for enhancing learning interactivity. IRS generally consists of hardware, including a set of simple personal handheld signal transmitters and a response signal receiver that are connected to a classroom computer to collect classroom members' responses, and software which is installed on a classroom computer to process the collected responses and demonstrate the results on a large display (i.e. TV or screen). IRS is not a new design concept. In 1985, IBM's "Advanced Technology Classroom" project used a simple IRS, called the Student Response System. It was originally applied for polling and supported several primary activities. The results of the research indicated that applying the IRS to questioning-and-answering could enhance learners' attention and achievements (Horowitz, 1988). Louis Abrahamson et al. invented another system called the Classroom Communication System (CCS), which was a prototype of Classtalk and applied to high school and university physics courses (Abrahamson, 1999). Recently, some commercial IRSs, such as the Personal Response System (PRS) (Cue, 1998) and the Classroom Performance System (CPS) (eInstruction, 2002) have also been developed.

Some later systems have been based on the design concept of IRS but also involved advanced personal handheld devices. For example, Classtalk used a calculator; Classtalk II used handheld computers/graphical calculators (Abrahamson, 1999), and Wireless Classroom developed by the authors' research team used Web PADs (Liu et al., 2003). These systems are very helpful for promoting interactions among participants in the classroom (Sarah, 2002; Liu et al., 2002), increasing students' conceptual understanding (Dufresne et al., 1996), enhancing students' learning achievements (Abrahamson, 1999; Hake, 1996), and actualizing the constructivist ideas (Liu et al., 2003). Although the IRS with transmitters has less computing power than systems that involve advanced personal handheld devices (Kou & Liu, 2001), this research will first focus on the former for several reasons. Firstly, the use of systems with advanced personal handheld devices increases the cost of constructing the learning environment - few schools, teachers or parents can afford such a cost. Moreover, although several IRS systems have been developed, only a few studies have clearly defined IRS and comprehensively described IRS's features and limitations. Developing and improving the relevant software can further enhance the utility, effects and efficiency of IRS in classroom instruction activities. Finally, the clarification of IRS's design concept could be helpful for further system design with other learning devices.

In sum, this paper has two essential purposes as follows. First, to clearly identify IRS's definitions, and through a survey of existing IRSs and comprehensive review of IRS-related research results to conclude major features regarding how the IRS enhances classroom interactions. Second, based on our finished and on-going research, this paper interprets how the IRS's existing features can be elaborated and expanded to other diverse applications from three aspects: 1. Developing a more powerful IRS, called EduClick II, for supporting various types of classroom activities and interactions; 2. Expanding IRS to a network-supported environment for teachers, students, and parents to benefit from application of the IRS without limitations of time and space; and 3. Expanding IRS to other advanced devices, and thus the devices with different computing power could possess IRS's existing features and more educational applicability.

Overview of Interactive Response System

Definition of IRS

The Interactive Response System (IRS), as referred to herein, is a technology-enabled learning environment for enhancing learning interactivity by transferring, collecting, processing, and displaying students' responses in an ordinary classroom. The general hardware and software of IRS are described as follows.

- **IRS hardware:** The IRS hardware includes two devices - a set of signal transmitters and the response signal receiver. IRS must operate in coordination with existing classroom facilities, such as a classroom computer and a large display, to actualize IRS's potential capabilities. The **signal transmitter** is a simple and

convenient personal handheld device with no computing power but with remote communication capability. In the classroom, every student can use this device to respond immediately to the teacher's requests. The **response signal receiver** receives the signal emitted from all signal transmitters and transfers these data to the classroom computer for further processing. The remotely communicating transmitter and receiver can be either wired or wireless, radio or infrared, with closed or open architecture, depending on the budget, number of participants, the classroom environment, and the applications employed. The **classroom computer**, connected to the receiver and the large display, is the brain of the IRS. All relevant software is installed on this computer, so the computer should have sufficient computing power to process response data transferred from the receiver. The **large display** is connected to the classroom computer to broadcast content and processed information to all participants. It should be large enough that it is clear to every student in the classroom. Figure 1 presents the configuration of the IRS.
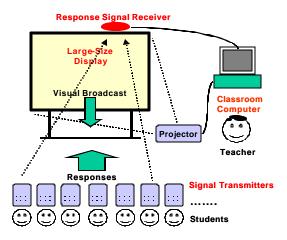

Figure 1: Typical IRS configuration in classroom

- **IRS software**: The software generally has the following basic functions: supporting the preparation of content (i.e. authoring materials), displaying content (i.e. showing materials on the screen), collecting all responses and processing them into meaningful information (i.e. grading students' answers), storing and retrieving processed information, and generating reports. The teacher and students can use these functions to engage in interactive learning activities.

Survey of IRSs

Existing IRSs are surveyed herein, and the technology in these systems and their interaction-supporting functions are reviewed. Common features of IRSs are thus identified to help in the design of a more useful IRS.

- **Student Response System (SRS):** Horowitz employed SRS, developed by Reactive Systems Inc. and originally designed to support business meetings, to enhance learners' interactivity in IBM's "Advanced Technology Classroom" in 1985 (Horowitz, 1988). SRS includes a set of simple numerical keypads as signal transmitters, which are cabled to a special hub box, which acts as a response signal receiver that is itself connected to the classroom computer. In Horowitz's study, teachers applied SRS to initiate the simplest interactive activity, questioning-and-answering. The results of the study reveal that after SRS was applied, the index of attentive behavior was increased from 47 to 83 and in some cases, learning achievements increased by 20 to 30%. Horowitz suggested that computer-supported interactive classrooms could enhance learning by supplying teachers with relatively inexpensive technology.

- **Classroom Communication System (CCS):** In 1988, Abrahamson and his partners invented CCS, which also used simple keypads as signal transmitters with wired technology (bE, 2003), to facilitate simple questioning-and-answering activities. Most researchers that use the system are physics teachers, so many applications of CCS are for high school and university physics courses. Prof. George Webb (1991) of Christopher Newport University first used this prototype system to initiate quiz activities for teaching over

150 students in an introductory physics lecture (Abrahamson, 1999). At the end of the semester, a survey of students showed that 90% claimed that they understood the subject better than they would otherwise have done and enjoyed the classes. Furthermore, Prof. Webb felt that all the students in the classroom were more active, livelier, and happier. In subsequent years, as CCS was upgraded to the Classtalk system using handheld computers, there are more in-depth researches. However, since Classtalk differs from IRS more than just by adopting a simple transmitter, it is not discussed here.

- **Other commercial IRS Systems:** Some commercial IRSs use simple but wireless devices, such as the Classroom Performance System (CPS) developed in 1995 by Hyper Graphic Inc. (eInstruction, 2003) and the Personal Response System (PRS) developed in 1997 by Nelson Cue, a professor at Hong Kong University of Science and Technology (Cue, 1998). Both IRSs use one-way inexpensive infrared technology. Such wireless technology enables students to carry the devices around the classroom. Some expensive IRSs, such as Fleetwood Company's Reply series, use RF technology. These systems support reliable two-way communication over longer distances, such as in a large classroom (Burnstein & Lederman, 2001).

System Name	Start Year	Personal Device	Communication Technology	Supported interactive functions	Manu-facturer
Student Response System	1985	Numeric Keypad	Wired	Q&A	Reactive System
Class Communication System	1988	Numeric Keypad	Wired	Q&A	Better Education
Reply(R)	near 1990	Numeric Keypad	Wireless RF	Q&A	Fleetwood
Classroom Performance System	1995	Numeric Keypad	Wireless IR	Q&A, Challenge Game	eInstruction
Personal Response System	1997	Numeric Keypad	Wireless IR	Q&A	Varitronix

Table 1: Comparison of IRSs

Table 1 compares various IRSs. Three key conclusions are drawn. First, the communication technology used in IRSs has advanced from wired to wireless. Second, most IRSs are developed primarily to support interactive Q&A activities. Finally, many IRS-related researches are pilot studies and focus on attention, achievement and motivation.

Common Features of Interactive Response Systems

After the IRSs and related studies were reviewed, four features of IRSs that enhance interactivity in the classroom were identified. All features are considered from both educational and technological perspective.

- **Device accessibility.** The ideal information technology-based classroom allows every student to have a computer. However, since most schools and parents cannot afford the cost of the equipment, each class usually has only a single classroom computer. Most teachers use the classroom computer to prepare instructional materials or display VCDs and slides, but students hardly access it. One of IRS's features is to enable many people to co-use one computer via their signal transmitters. With support of computer software, the computing power of the classroom computer could be used to access and process each student's responses. Therefore, IRS provides device accessibility.

- **High efficiency.** When students input something using signal transmitters, the IRS collects the inputs and processes them simultaneously using almost parallel-processing (Brandt & Lonsdale, 1996). The task is performed more efficiently than were a human to perform it. For example, in a traditional paper-pen test, the teacher should give students the test papers, collects the finished test papers, grades the answers, records the scores, and finally returns the graded test papers. IRS is an effective tool for reducing the time spent by teachers and their workload associated with such tasks. IRS can immediately collect and process all students' responses, helping teachers understand all students' learning statuses, and helping them make decisions instantly during class.

- **Response display.** The large display shows two types of response information during IRS activities. The first is students' response statuses, such as which student is responding or changing his/her response, how many people have responded, and the response-speed of whole class. When students look at the large display to understand the response status, their responding motivation and speed may be affected. If the teacher finds that students' responses are faster than usual, the question may be simpler or intuitive but perhaps not relatively many students have the correct answer. The second type of information on the display statistically summarizes students' responses, such as charts, an average or a correct rate. The teacher and students gain feedback and can reflect before proceeding with interactive activities, based on this information. Furthermore, the teacher can judge whether he/she should revise instructional activities according to this information, which function is key to IRS's enabling of discussions.

- **Anonymity.** Using the handheld signal transmitter in hand, each student can send his/her own responses privately. After IRS collects all students' responses, the teacher can either display statistical results of the whole class or display what individual student responds. If the latter function is not used, the IRS supports anonymity. Anonymity is very important in test activities, during which the teacher does not allow anyone to know others' answers. Besides, anonymity allows individual students to think without being interrupted by other students' choices during votes or survey activities. Sarah (2002) also pointed out that anonymity facilitates students' exploration of answers without feeling threatened. Moreover, anonymity helps students focus on the merits of the contributed idea rather than its source (Kwok & Ma, 1999).

Expanding IRSs Based on their Features

Our survey and review show that using the IRS with their features in ordinary classrooms can provide teachers and students with many advantages, such as the teacher can save time for collecting and grading students' test papers, each student is enabled to gain feedback and respond immediately via his/her own signal transmitter, and students' responses can be reserved, statistically summarized, and displayed in different ways. Nevertheless, our research team assumed that IRS's existing features can be expanded and applied to some extent. The following sections ground on our finished and ongoing research to illustrate: how to make an IRS better fit in with teachers' in-class needs and support various types of instruction and learning activities, how to enables more people with different needs, such as students, parents, and teachers, to benefit from using IRSs anytime, anywhere, and how to substantially promote the device's instructional applications through expanding IRS's design concepts to the devices with different computing power.

Expanding IRS's Application Capabilities for In-class Instruction

Even though the four features of IRS described earlier can effectively facilitate in-class interactive learning and instruction, the main function of most existing IRSs is merely to support simple Q&A activities. The essential issue is how to apply IRS to various instruction and learning activities by developing and improving software and designing hardware. Accordingly, our research team designed and created the EduClick I in 1999 (Liang et al., 2001). From 1999 to 2002, we cooperated with a group of teachers to conduct field studies in the classroom and obtained suggestions for improvements. According to the feedback from the participants, we developed EduClick II in 2002, which includes the following features. First, to reduce the cost of the device, infrared communication techniques are used to enhance delivery of information. Consequently, the system is not limited by classroom space and can effectively send and receive users' responses. Second, to enable teachers to "effectively" and "conveniently" integrate EduClick II into the instruction of each subject, five subsystems were designed to help teachers to (1) manage basic information about class members, (2) edit, re-classify and manage needed instructional materials used in EduClick-based instruction, (3) grasp easily the entire process of integrating EduClick II into instruction, (4) understand thoroughly students' learning statuses when using EduClick II, and (5) conclude and sort data on students' interactions into various useful data tables, which are helpful in managing students' response data and understand their answers. Finally, EduClick II has two types of interaction-supporting modes, quiz mode and statistical mode, to enable teachers "flexibly" to integrate EduClick II into "various" learning and instruction activities according to different needs. Teachers may flexibly combine various modes to overcome the obstacles in carrying out interactive activities in the classroom and effectively implement various interactive instructions and

types of learning (elucidating students' learning statuses, arousing their motivation to learn and promoting whole-class and group discussion). According to the survey and interviews conducted herein with teachers who had actually used EduClick II, the added features of EduClick II efficiently enhance the utility of the classroom computer and facilitate the integration of information technology into instruction, effectively improving students' attentiveness and motivation to learn, as well as the quality of the teachers' instruction.

Expanding IRS to Benefit More People Via a Network-supported Environment

This section describes how EduClick II and the virtual city created by our research team, called EduCities, can be combined to be a "network-supported environment." Such an environment enables teachers to break through the classroom's limitations to share and exchange instructional materials with each other, allows parents to understand their children's performance at school, and facilitates students' reviewing and reflecting on the teacher's questions during class.

EduCities was set up by researchers from several universities in Taiwan (Chan et al, 2001). The structure and operation of EduCities are like those of a real city, to cultivate a learner-oriented learning society on a network. Citizens of this cyber city include students, teachers, parents, and anyone who is willing to participate and contribute. EduCities represent a distributed system with several layers. The first layer, also named EduCities, is the headquarters of the entire system. EduTowns, the second layer, comprises the servers of the participating schools. EduVillages, the third layer, consists of the servers of "classes". Figure 7 shows the layers of the EduCities. Currently over 2,000 schools, more than half the schools in Taiwan, have established EduTowns, and more than 20,000 classes have developed EduVillages (EduTowns, 2003).
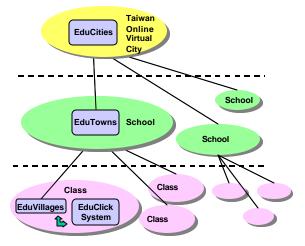

Figure 7: Multiple-layer EduCities

The purpose of combining EduClick II and EduVillages is to assist teachers in preparing instructional materials, supporting their in-class instruction and learning activities, and collecting students' responses. Through EduTowns, teachers at the same school can cooperate/collaborate to prepare and share instructional materials; parents of each class member can review their child's in-class performance, and students can review and discuss the instruction. Through EduCities, all teachers who have used EduClick II can share and exchange instructional materials. In brief, the framework of the three layers whose center is EduClick II brings teachers, students and parents into an EduClick-based community.

Expanding IRS to Other Advanced Devices

Even though EduClick II uses less advanced and inexpensive hardware devices, its software design (i.e. interaction-supporting modes) can be developed and extended to more advanced devices, such as mobile phones, PDAs, WebPADs, notebooks, and Tablet PCs. Presently, our research team is using the WebPAD as each student's personal handheld device and merging the software design concepts to construct a Wireless Classroom. Empirical classroom

research indicates that instruction in the Wireless Classroom facilitates teacher-student and peer interaction (Liu et al., 2002). In the near future, we plan to improve EduClick's capabilities and adopt Besta's "English-Chinese electronic dictionary" as a learning device (Besta, 2002). This dictionary is already very popular in Taiwan and has become a necessary tool for reading and learning English. It has a mini QWERTY keyboard and small LCD display that can overcome some of the limitations of the current EduClick II transmitter, such as one-key entry, the lack of confirmation of transmission, and the lack of an alphabetic entry. In addition, we find that the electronic dictionary along with add-on programs is a problem-solving accessory for English and other subjects, and think that it is very helpful to extend interaction-supporting modes.

Conclusion

In using information technology to improve learning and instruction and to help teachers overcome limitations on interactions in traditional classrooms, a primary goal is to provide students with many opportunities to access information technology during instruction. Accordingly, the devices used must be effective and affordable. Many classrooms currently have only a single computer. Since students have few opportunities to access the computer during instruction, the classroom computer is not fully utilized and thus the technology does not help overcome the limitations of classroom interactions for class members.

Integrating IRS with the classroom computer into instruction is an inexpensive and effective solution. However, little research has comprehensively reviewed IRS. This study reviewed the IRS and found that its "device accessibility" feature enables teachers to employ a handheld signal transmitter remotely to control the display of instructional materials and questions, allowing each student to use his/her own signal transmitter to respond to the teacher's instruction and questions. The "high efficiency" feature permits teachers to know students' responses to support further decision-making. The "response display" feature provides a focus of interaction for the whole class. The "anonymity" feature helps students avoid unnecessary interference from each other.

Based on the four common features of IRSs, this paper takes EduClick as an example to address three issues. First, with the innovation and improvement of IRS software, IRS can work more effectively to support teachers to edit and manage IRS-based instruction materials, monitor and apply students' learning portfolio in using IRS, and flexibly apply the system to different types of classroom activities. Second, the integration of the IRS and network-supported environment enables members in different groups and with different needs can take advantage of IRS's in-class applications without the constraints of time and space, such as allowing teacher communities to develop, share, and discuss self-edit IRS-based materials, enabling students to review the materials on the IRS and check their responses during class, and making students' parents understand students' in-class performance in using IRS to interact with others. Finally, by integrating IRS's features into devices of different levels, the application of the device to instruction and learning can be further expanded and extended.

Although the hardware technology adopted by IRSs is neither innovative nor advanced, their low-cost and classroom interaction-enhanced features make their real classroom application potential and promising. In addition to conducting field study regarding the three aspects of expanding and applying IRS, future study needs to further explore other possible application aspects.

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