Handbook of Research on New Media Literacy at the K–12 Level: Issues and Challenges

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Understanding Factors that Influence the Effectiveness of Learning Objects in Secondary School Classrooms

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ABSTRACT

The design, development, reuse, and accessibility of learning objects has been examined in some detail for almost 10 years (Kay & Knaack, 2007c, 2007d), however, research on the effectiveness of learning objects is limited (Kay & Knaack, 2005; Nurmi & Jaakkola, 2006a, 2006b, Sosteric & Hesemeier, 2004), particularly in the K-12 environment. Until recently, learning objects were solely used in higher education (Haughey & Muirhead, 2005; Kay & Knaack, 2005, 2007c). The purpose of the current chapter is to examine factors that influence the effectiveness of learning objects in secondary school classrooms. These factors will include learning object qualities, gender, self-efficacy, grade, subject area, and teaching strategies.

INTRODUCTION

Definition of Learning Objects

It is important to establish a clear definition of a “learning object” in order to assess effectiveness. Unfortunately, consensus regarding a definition has yet to be attained (e.g., Bennett & McGee, P., 2005; Metros, 2005; Muzio, Heins, & Mundell 2002; Parrish, 2004; Wiley, et al. 2004). Part of the problem rests in the values and needs of learning object developers and designers. The majority of researchers have emphasized technological issues such accessibility, adaptability, the effective use of metadata, reusability, and standardization (e.g., Downes, 2003; Koppi, Bogle, & Bogle, 2005;
Understanding Factors that Influence the Effectiveness of Learning Objects

Muzio et al., 2002; Siqueira, Melo, & Braz, 2004). However, a second “learning focussed” pathway to defining learning objects has emerged as a reaction to the overemphasis of technological characteristics (Baruque & Melo, 2004; Bradley & Boyle, 2004; Cochrane, 2005; Wiley et al., 2004).

While both technical and learning-based definitions offer important qualities that can contribute to the success of learning objects, research on the latter is noticeably absent (Kay and Knaack, 2007b, 2007d). Agostinho, Bennett, Lockyear & Harper (2004) note that we are at risk of having digital libraries full of easy to find learning objects we do not know how to use in the classroom.

In order to address a clear gap in the literature on evaluating learning objects, a pedagogically focussed definition of learning objects has been adopted for the current chapter. Learning objects are as defined as “interactive Web-based tools that support the learning of specific concepts by enhancing, amplifying, and guiding the cognitive processes of learners”. See Kay & Knaack (2008a) for concrete examples of the learning objects examined.

Benefits of Learning Objects

Over the past 10 years, a substantial effort has been made to increase the use of technology in the classroom (Compton & Harwood, 2003; McRobbie, Ginns, & Stein, 2000; Plante & Beattie, 2004; US Department of Education, National Center for Education Statistics, 2002). In spite of these efforts, a number of researchers have argued that technology has had a minor or negative impact on student learning (e.g., Cuban, 2001; Roberston, 2003; Russell, Bebell, O’Dwyer, & O’Connor, 2003; Waxman, Connell, & Gray, 2002). Part of the problem stems from a considerable list of obstacles that have prevented successful implementation of technology including a lack of time (Eifler, Greene, & Carroll, 2001; Wepner, Ziomek, & Tao, 2003), limited technological skill (Eifler et al., 2001; Strudler, Archambault, Bendixen, Anderson & Weiss, 2003; Thompson, Schmidt, & Davis, 2003), fear of technology (Bullock, 2004; Doering Hughes, & Huffman, 2003), a clear lack of understanding about how to integrate technology into teaching (Cuban, 2001), and insufficient access (e.g., Bartlett, 2002; Brush et al., 2003; Russell et al., 2003).

Learning objects offer a number of key components that can reduce the impact of potential obstacles observed in the past (accessibility, ease of use, reusability) and enhance student learning (interactivity, graphics, reduction of cognitive load, adaptive).

In contrast to former learning technologies burdened with barriers to development and implementation, learning objects are readily accessible over the Internet and users need not worry about excessive costs or not having the latest version (Wiley, 2000). Well over 90% of all public schools in North America and Europe now have access to the Internet (and therefore learning objects) with most having high-speed broadband connections (Compton & Harwood, 2003; McRobbie, Ginns, & Stein, 2000; Plante & Beattie, 2004; US Department of Education, National Center for Education Statistics, 2002). In addition, because of their limited size and focus, learning objects are relatively easy to learn and use, making them much more attractive to busy educators who have little time to learn more complex, advanced software packages (Gadanidis et. al., 2003). Finally, reusability permits learning objects to be useful for a large audience, particularly when the objects are placed in well organized, searchable databases (e.g., Agostinho et al., 2004; Duval, Hodgins, Rehak & Robson, 2004; Rehak & Mason, 2003).

With respect to enhancing learning, many learning objects are interactive tools that support exploration, investigation, constructing solutions, and manipulating parameters instead of memorizing and retaining a series of facts. The success of this constructivist based model
is well documented (e.g., Albanese & Mitchell, 1993; Bruner, 1983, 1986; Carroll, 1990; Caroll & Mack, 1984; Collins, Brown, & Newman, 1989; Vygotsky, 1978). In addition, a number of learning objects have a graphical component that helps make abstract concepts more concrete (Gadanidis et al., 2003). Furthermore, certain learning objects allow students to explore higher level concepts by reducing cognitive load. They act as perceptual and cognitive supports, permitting students to examine more complex and interesting relationships (Sedig & Liang, 2006). Finally, learning objects are adaptive, allowing users to have a certain degree of control over their learning environments, particularly when they are learning and for how long.

**Use of Learning Objects in Secondary Schools**

Only four published studies were found investigating the use of learning objects with secondary school students (Brush & Saye, 2001; Kay & Knaack, 2007c; Lopez-Morteo & Lopez, 2007; McCormick & Li, 2005).

*Teacher perspective.* Two studies looked at how teachers viewed learning objects (Kay & Knaack, 2007c; McCormick & Li, 2005). Kay & Knaack (2007c) reported preservice and experienced teachers strongly agreed that:

a. Learning objects were a beneficial tool for students,

b. They helped students with respect to understanding concepts, and

c. They would be interested in using the learning objects in their classrooms again.

McCormick & Li (2005) noted that 60 to 75% of teachers felt learning objects were useful and enjoyed using learning objects, although over 50% reported technical problems local to their schools.

*Student perspective.* Brush & Saye (2001) observed that students tended to look at superficial content in a learning object when left to their own devices and that more active guidance and structure was needed when using information-based learning objects. Kay & Knaack (2007c) used a comprehensive assessment measure and reported that students were moderately positive about learning objects. In addition, overall usefulness, clear instructions, organized layout and good theme/motivation were particularly important to students. Finally, Lopez-Morteo & Lopez (2007) reported that students perceived interactive, recreation-based, collaborative learning objects positively.

*Student performance.* To date, no studies have been done looking at the impact of learning objects on the performance of secondary school students.

**Purpose**

The goal of this chapter is to look closely at the kind of factors that can influence the effectiveness of learning objects in secondary school classrooms. A comprehensive review of the literature has revealed the following factors as potential influences on learning object effectiveness:

- Learning object qualities
- Gender
- Computer comfort
- Grade
- Subject area
- Teaching strategies

**METHOD**

**Overview**

In order to address the key methodological challenges noted in previous evaluation of learning objects, the following steps were taken:
1. A large, diverse, sample was used;
2. Reliability and valid surveys were used;
3. Formal statistics were used where applicable;
4. Both teacher and student perspectives were assessed;
5. A measure of student performance was included; and
6. A wide range of learning objects in a variety of subject areas was tested.

Sample

Teachers. The teacher sample consisted of 27 teachers (12 males, 15 females) and 50 classrooms (a number of teachers used learning objects more than once). Teaching experience ranged from 1 to 33 years with a mean of 9.2 (SD = 8.2). Subject areas taught were science (biology, chemistry, general science, physics, n=15), math (n=10), and social science (geography, history, n=2). A majority of the teachers rated their ability to use computers as strong or very strong (n=23) and their attitude toward using computers as positive or very positive (n=23). However, only six of the teachers used computers in their classrooms more than once a month.

Students. The student sample consisted of 850 secondary school students (444 males, 406 females) ranging in age from 10 to 22 years (M = 16.5, SD = 1.1). The population base spanned three separate boards of education, 15 secondary schools, and 27 different classrooms. The students were selected through convenience sampling and had to obtain signed parental permission to participate.

Learning Objects. A majority of teachers selected learning objects from a repository located at the LORDEC Website (Kay & Knaack, 2008c), although several reported that they also used Google. A total of 33 unique learning objects were selected covering concepts in biology, chemistry, general science, geography, mathematics, and physics. To view specific examples of learning objects used by teachers in this study, see Kay & Knaack (2008a).

Procedure

Each teacher received a half day of training in November on how to choose, use, and assess learning objects (see Kay & Knaack, 2008d for more details on the training provided). They were then asked to use at least one learning object in their classrooms by April of the following year. It is important to note that teachers were given full control over the learning object they chose and how they used it in the classroom.

Email support was available throughout the duration of the study. All students in a given teacher’s class used the learning object that the teacher selected. However, only those students with signed parental permission forms were permitted to fill in an anonymous, online survey about their use of the learning object. In addition, students completed a pre- and post-test based on the content of the learning object.

Data Sources

Student survey. After using a learning object, students completed the Learning Object Evaluation Scale for Students (LOES-S) to determine their perception of how much they had learned (learning construct), the quality of the learning object (quality construct) and how much they were engaged with the learning object (engagement construct). The constructs selected were based on a thorough review of the literature (Kay & Knaack, 2005, 2007b, 2007c, 2007d). The scale showed good reliability (0.78 to 0.89), face validity, construct validity, convergent validity and predictive validity (see Kay & Knaack, 2007b).

Student performance. Students completed a pre-test and post-test based on the content of the learning object used in class. The difference between pre- and post-test scores was used to determine student performance.
### RESULTS AND DISCUSSION

#### Impact of Learning Object Characteristics

**Background.** With few exceptions (e.g., Kay & Knaack, 2005; Reimer & Moyer, 2005), the analysis of ‘learning’ in learning objects has remained largely theoretical. A detailed review of learning object research revealed five main evaluation criteria (Kay & Knaack, 2007a): interactivity, design, engagement, usability, and content. These criteria were identified based on a comprehensive review of the literature on instructional design (Kay & Knaack, 2007a) and key learning object evaluation models used previously (Cochrane, 2005; Haughey & Muirhead, 2005; Howard-Rose & Harrigan, 2003; Kay and Knaack, 2005, 2007c; Nesbit and Belfer, 2004).

With respect to **interactivity**, key components considered by researchers included promoting constructive activity, providing a user with sufficient control, and degree of interaction. The underlying theme was that learning objects should provide rich activities that open up opportunities for action, rather than prescribed pathways of learning (Brown & Voltz, 2005). When looking at **design**, investigators focused on layout, degree of personalization, quality of graphics, and emphasis of key concepts. Evaluation of **engagement** has incorporated difficulty level, theme, aesthetic appeal, feedback, and inclusion of multimedia. Assessment of **usability** has referred to overall ease of use, clear instructions, and navigation. Finally, with respect to **content**, the predominant features looked at have been the integrity and accuracy of material presented. However, in this study, teachers probably filtered “content” issues when they selected a learning object for their class. In other words, it is unlikely that they selected learning objects that did not have the correct content and scope.

Therefore, four characteristics of learning objects were used to assess effectiveness of learning objects examined for this chapter: interactivity, design, engagement, and usability. Reliability and validity were determined to be good for these constructs (Kay & Knaack, 2007a).

**Results - Student Perceptions.** For students, good design \((r=0.25, p<.001)\), higher engagement \((r=0.24, p<.005)\), and better usability \((r=0.28, p<.001)\) of a learning object significantly correlated with higher perceptions of learning. Interactivity, on the other hand, was not related to perceptions of learning \((r=0.06, \text{n.s.})\).

**Results - Learning Performance.** Mean class learning performance (percent change from the pre- to the post-tests) was significantly and positively correlated with interactivity \((r=0.28; p<.005, n=119)\), design \((r=0.43; p<.001, n=116)\), engagement \((r=0.37; p<.005, n=84)\), and usability constructs \((r=0.40; p<.001, n=120)\).

**Conclusion.** It appears that the well designed, engaging learning objects are the most effective with respect to student perceptions of learning, as well as gains in student performance. Usability is also an important characteristic, but only with respect to student perceptions of learning and student performance. It is quite possible that teachers are unaware of the student usability issues, and therefore underestimate the impact. Finally, students did not perceive interactivity as a critical factor in learning. This is an interesting finding that somewhat contradicts proponents of a more constructivist design. Nonetheless, interactivity in learning objects was positively associated with significantly higher learning performance.

#### Impact of Gender

**Background.** Numerous studies have investigated the role of gender in computer behaviour (see AAUW, 2000; Barker & Aspray, 2006; Kay, 1992; Sanders, 2006; Whitley, 1997 for detailed reviews of the literature) and the following conclusions can be made. First, most studies have looked at computer attitude, ability, and/or use. Second, roughly 30 to 50% of the studies report differences
in favour of males, 10-15% in favour of females, and 40 to 60% no difference. Third, differences reported, while statistically significant, are often small. Overall, one could say there is a persistent pattern of small differences in computer attitude, ability, and use that favours males, however considerable variability exists (Kay, 2008b).

Results. A MANOVA was run for gender and the three student constructs (learning, quality, and engagement) and revealed no significant difference between male and female students. In addition, a t-test showed no significant gender differences with respect to student performance.

Conclusion. Given that gender differences have been fairly small, but persistent over the past 25 years (AAUW, 2000; Barker & Aspray, 2006; Kay, 1992; Sanders, 2006; Whitley, 1997), one might have expected differences to emerge with respect to learning objects. However, no significant differences were observed between males and females for any of the four dependent student variables. This finding is consistent with the results reported by Kay & Knaack (2007e) on secondary school students.

One of the reasons that learning objects may be relatively gender neutral with respect to perceived learning and student performance is because they are easy to use. In the past, females have reported being less confident and able to use computers. However, easy to use learning objects may minimize the impact of confidence and computer ability. It is also conceivable that the population examined in this study, namely secondary students, may be representative of a new trend citing fewer gender differences (Kay, 2008b). The fact that males and females did not differ with respect to computer comfort level provides indirect evidence that gender differences at the secondary school level may be disappearing.

Impact of Self-Efficacy

Background. Considerable research has been done looking at the effect of attitude on computer related behaviour (Barbeite & Weiss, 2004; Christensen & Knezek, 2000; Durndell & Haag, 2002; Kay, 1989, 1993; Liu, Hsieh, Cho, & Schallert, 2004; Torkzadeh, Pflughoeft, & Hall, 1999). As one might predict, more positive computer attitudes are generally associated with higher levels of computer ability and use. Self-efficacy or perceived comfort with using computers has been shown to be particularly influential on knowledge and use of computers (e.g., Barbeite & Weiss, 2004; Durndell & Haag, 2002).

Results. Computer comfort was assessed using a scale developed by Kay & Knaack (2005) which should good construct validity and high reliability. The internal reliability for the scale used in this study was 0.81. Correlations among computer comfort and student perceptions of learning ($r = 0.30 \pm 0.06, p < .001$), quality ($r = 0.26 \pm 0.07, p < .001$), and engagement ($r = 0.30 \pm 0.06, p < .005$) were significant. Student performance, though, was not significantly correlated with computer comfort ($r = 0.01 \pm 0.09, ns$). Note that males and females did not differ significantly with respect to computer comfort.

Conclusions. Secondary students who were more comfortable with computers tended to rate perceived learning, quality, and engagement of learning objects higher than students who were less comfortable. This result is consistent with previous research on self-efficacy and computer related behaviour. In addition, the lone study looking at secondary school students and learning objects (Kay & Knaack, 2007e) reported a similar finding. The critical point, though, is that computer comfort was not related to student performance. Students with lower computer self-efficacy may not have liked using the learning objects as much as their more confident peers, but performance was largely unaffected. One of the key attributes of learning objects, ease of use, may have tempered the negative impact of computer self-efficacy.
Impact of Grade Level

Background. A number of researchers have examined differences in computer attitude and ability among various age groups, albeit in a somewhat patchwork manner. Older students (15-16 years old), for example, viewed computers as tools for accomplishing tasks and getting work done (e.g., word processing, programming, use of the Internet, and email), whereas younger students (11-12 years old) saw computers as a source of enjoyment (e.g., play games and use graphics software) (Colley, 2003; Colley & Comber, 2003; Comber, Colley, Hargreaves, & Dorn, 1997).

Grimes, Hough, & Signorella (2007) looked at a larger age range and reported that working age adults used computers more and spent more hours online than either college students or retirees. Zhang (2005) added that younger employees felt the internet was more useful than older age groups. On the other hand, Harris & Granfgenett (1996) and Kubek, Miller-Albrecht & Murphy (1999) observed that age had a negligible affect on computer attitudes.

Grade has not been looked at extensively, although one study reported that grade 11 students were less anxious than grade seven and nine students (King, Bond, & Blandford, 2002). More research needs to be done in this area, particularly in teasing out the differential impact of age and grade. It is unclear whether differences observed in computer related behaviour are a result of advances in cognitive and emotional maturity (age) or whether they are due to the increased academic importance that may increase with grade level.

Results. A MANOVA was run for student perceptions of how much they learned, the quality of the learning object, and the extent to which they were engaged as a function of grade. Significant differences were observed for all three constructs. With respect to students perceptions of learning, a multiple comparisons analysis indicated that grade 12 students rated learning objects significantly higher than grade 9 and 10 students (Scheffé post hoc analysis, \( p < .05 \)). Regarding, students perceptions of learning object quality, grade 12 students had significantly higher scores than grade 9 and 10 students (Scheffé post hoc analysis, \( p < .01 \)). In addition, grade 11 students rated learning objects higher than grade 10 students in terms of learning quality (Scheffé post hoc analysis, \( p < .005 \)). Finally, for students perceptions of engagement, grade 12 student scores were higher than grade 10 scores (Scheffé post hoc analysis, \( p < .05 \)).

A one-way ANOVA examining student performance as a function of grade level was significant (\( p < .001 \)). Grade 12 students (\( M = 29.6\%, SD = 27.4\% \)) performed better than grade 10 (\( M = 10.9\%, SD = 27.6\% \); Scheffé post hoc analysis, \( p < .001 \)) and grade 9 (\( M = 15.9\%, SD = 23.6\% \); Scheffé post hoc analysis, \( p < .05 \)) students on their respective learning objects. In terms of change from pre-post test score, grade 12 students appeared to have a 14 to 19 percent advantage over grade 9 and 10 students. As well, grade 11 students (\( M = 24.3\%, SD = 26.1\% \)) had higher performance scores than grade 10 students (Scheffé post hoc analysis, \( p < .005 \)).

Conclusion. Grade 12 students had significantly higher scores on all four dependent variables when compared to grade 10 and 9 students. Kay & Knaack (2007) observed a similar result with secondary school science students. At first, this result might seem somewhat counterintuitive, given that younger students are typically exposed to more technology than their older peers. Furthermore, the culture of high school has not been ingrained in grade 9 and ten students, as much as it has in grade 11 and 12 students. Younger students should be more open to new teaching strategies. However, other grade-specific ‘cultural’ factors may come into play. For grade 12 students, succeeding is more important, particularly for students wishing to move on to higher education. For grade 9 and 10 students, the urgency of having to perform well may not have emerged yet.

In addition, previous research suggests that older students view a computer as a tool to
Understanding Factors that Influence the Effectiveness of Learning Objects

support learning, whereas younger student see computers as a means of entertainment (Colley, 2003; Colley & Comber, 2003; Comber, Colley, Hargreaves, & Dorn, 1997). Learning objects are typically designed to promote learning, not fun – a goal that would more closely match the needs of the older students. Finally, it is possible, as suggested earlier, that learning objects work better for older students.

Impact of Subject Area

Background. No studies could be found looking at individual differences in computer behaviour as a result of subject taught, although several researchers have examined the use of computers in mathematics (e.g., Forgasz, 2006) or science classes (e.g., MacKinnon, 2003). The impact of subject area on computer attitude and performance, then, is unknown.

Results. A MANOVA was run for student perceptions of how much they learned, the quality of the learning object, and the extent to which they were engaged as a function of subject taught. Significant differences were observed for all three constructs. A multiple comparisons analysis revealed that science students rated learning objects higher than math students with respect to perceived learning (Scheffé post hoc analysis, \( p < .001 \)), quality of the learning object (Scheffé post hoc analysis, \( p < .001 \)) and the engagement value (Scheffé post hoc analysis, \( p < .001 \)). In addition, science students rated quality (Scheffé post hoc analysis, \( p < .01 \)) and engagement (Scheffé post hoc analysis, \( p < .05 \)) significantly higher than social science students.

A one-way ANOVA examining student performance as a function of subject taught was significant (\( p < .001 \)). Science students (\( M=25.9\% \) increase, \( SD 26.7\% \)) performed better than math (\( M = 2.8\% \) increase, \( SD 22.4\% \); Scheffé post hoc analysis, \( p < .001 \)) and social science students (\( M = 12.4\% \) increase, \( SD 17.4\% \); Scheffé post hoc analysis, \( p < .05 \)). In addition, social students had higher performance scores than math students (Scheffé post hoc analysis, \( p < .05 \)).

Conclusion. It is somewhat surprising that subject differences emerged in favour of science students over mathematics and social science students. The sample size for the social science population was small, therefore the results observed should be viewed with caution. On the other hand, the availability of social science learning objects was relatively small compared to science and mathematics. Lower scores may simply reflect poorer quality learning objects.

The differences between science and mathematics are harder to explain, since the number of learning objects available for each subject area was similar. There is no reason to believe that science teachers, on average, selected better learning objects than mathematics teachers. It is possible that science based concepts are more concrete and easier to relate to the real world making them more appealing than more abstract mathematics concepts. This fundamental difference may make science-based learning objects intrinsically more attractive and therefore more successful. It is critical in future research to ask students about their attitude toward a particularly subject area in order to test this hypothesis.

Impact of Teaching Strategy

Background. The agenda for the majority of articles written to date has been to look at the design and developmental process of stand-alone objects that are readily accessed and reused (e.g., Kong & Kwok, 2005; Oliver & McLoughlin, 1999; Poldoja, Leinonen, Valjataga, Ellonen, & Priha, 2006). Only a handful of studies have examined the impact of individual teaching strategies used with learning objects and no studies have compared strategies. However, a substantial number of theorists (Alonso, Lopez, Manrique, & Vines, 2005; Bratina et al., 2002; Haughey & Muirhead, 2005; Koppi et al., 2004; McCormick & Li, 2005; Moyer, 2001; Thorpe, Kubiak, & Thorpe, 2003)
believe that how a teacher chooses to use a learning object is critical for successful implementation.

Results. It was anticipated that strategies for social science might vary considerably from math and science, so only math and science subject areas were looked at to provide a more homogenous sample. The following teaching strategies for using the learning objects in a classroom were examined: (a) independent use of computers, (b) introducing the learning object, (c) supports provided for learning object use, and (d) consolidation of a learning object lesson.

Independent use of computers. Almost all teachers (97%) chose to have students work independently on their own computers. Choosing to have students work independently on computers as opposed to in pairs or larger groups was not significantly related to student perceptions of learning, learning object quality, and engagement nor was it related to student performance.

Introducing the learning object. With respect to introducing the learning object, 62% of the teachers provided a brief introduction and seven percent formally demonstrated the learning object. Demonstrating a learning object or providing a brief introduction was not significantly related to the four dependent variables used in this study (learning, quality, engagement, student performance). Simply letting students explore on their own, though, was significantly and positively correlated to student perceptions of improved learning ($t = 2.88, df = 469, p < .005$) and higher perceptions of quality ($t = 2.29, df = 459, p < .05$), but not perceptions of engagement. Student performance dropped significantly (11% decrease), though, if students were left to explore on their own (Table 4).

Supports provided. In terms of supports provided, 35% of the teachers created a set of guiding questions, while 28% provided a worksheet. If a teacher created a set of guiding questions, students rated learning ($t = -3.23, df = 469, p < .005$) and learning object quality ($t = -2.33, df = 459, p < .005$) higher, but not engagement. Student performance increased significantly by 13% ($p < .001$). When worksheets were provided, students rated learning ($t = -2.29, df = 469, p < .05$) and learning object quality ($t = -2.27, df = 459, p < .05$) higher, but not engagement. Student performance was unaffected.

Consolidation. Thirty-eight percent of teachers chose to discuss the learning object after it had been used. When teachers chose to discuss the learning object after students worked with it, students rated learning ($t = -2.71, df = 469, p < .005$) and learning object quality ($t = -4.65, df = 459, p < .001$) lower, but not engagement. Student performance decreased significantly by 11% ($p < .001$).

Conclusion. Four areas of integration were evaluated in this study. First, the decision to have students work independently on computers and not in pairs was made by 97% of the teachers. While there was no difference between student attitude and performance between independent and cooperative use of computers, this result is compromised by disparate sample sizes.

Second, providing a brief or extended introduction appeared to be necessary, but not sufficient for improving student attitudes and performance. While the type of introduction (brief vs. extended) was unrelated to student perceptions and learning outcomes, post-test scores were significantly lower if students were simply allowed to explore on their own. Paradoxically, students preferred the “explore on your own” approach. In this situation, students’ attitudes were not the best predictor of student performance. Some type of introduction and guidance is probably a good starting strategy when using learning objects. This result is consistent with previous research on providing sufficient context (Schoner et al., 2006).

Third, regarding the provision of instructional supports, the results of this study are consistent with previous studies suggesting that worksheets or guiding questions are essential for the successful use of learning objects (Brush & Saye, 2001; Concannon, Flynn, & Campbell, 2005;
Understanding Factors that Influence the Effectiveness of Learning Objects

Lim, Lee, & Richards, 2006; Mason, Pegler, & Weller, 2005; Mayer, 2004). However, the precise nature of supports appears to be important. When simple worksheets were used, student performance was unaffected, but when guiding questions were offered, student performance increased significantly. Guiding questions may have offered a clearer pathway to the intended goals of the lesson.

Finally, somewhat surprisingly, consolidation or class discussion after the use of a learning object appears to have a negative affect on student attitude and learning performance. This finding is opposite to what one would expect. One explanation might be that class discussion was used when the use of learning objects did not go smoothly, when there were problems, and perhaps when confusion was experienced by students. A more detailed description of the discussion is required to fully understand this result.

**SUMMARY AND IMPLICATIONS FOR EDUCATION**

A thorough review of the research identified six factors that might either enhance or inhibit the effectiveness of learning objects. The results are summarized in Table 1.

This chapter explored factors that influence the effectiveness of learning objects in the secondary school classroom. It would be somewhat premature to offer definitive advice for educators based on one study. That said, several tentative suggestions may be worth considering.

1. It appears that a well designed learning object that is easy to use and engaging will have the most positive impact on student attitude and learning.

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428
Understanding Factors that Influence the Effectiveness of Learning Objects

2. Gender differences in attitude and performance may not be a concern when using learning objects.

3. Self-efficacy or computer comfort level may be a problem with respect to attitude toward learning objects, but it does not appear to affect performance. Teachers can be somewhat confident that their less computer savvy students will not be disadvantaged when these tools are being used.

4. Students in higher grades (e.g., grade 11 and 12) appear to be more receptive to learning objects than students in lower grades (e.g., grade 9 and 10). It is speculated that younger students may need more structure, guidance, and support when using learning objects.

5. Learning objects may be more successful in science than in mathematics, although the reason for this is unclear. Perhaps more effort is needed to establish context and engagement with mathematics based learning objects.

6. The most effective strategy selected by teachers was to provide a set of guiding questions. A less effective strategy involved letting students explore on their own without direction.

FUTURE RESEARCH

The quantitative measures used to assess effectiveness of learning objects in this study were reliable and valid, and one can be reasonably confident that certain factors play a significant role in determining the effectiveness of learning objects. However, it is unclear why some factors are more influential than others. More detailed qualitative analysis in the form of interviews, focus groups, or open ended questions is needed to look at:

a. Why grade level differences are observed in the use of learning objects;

b. Why subject differences were observed;

c. How does attitude toward a specific subject area influence the impact of learning objects;

d. How effective are learning objects in other subject areas such as English, French, business, and computer science;

e. How does ability in a specific subject influence the effectiveness of learning objects;

f. Why consolidation leads to lower student performance

In addition, while providing guiding questions proved to be a successful strategy, the actual quality of questions was not examined. It is possible that certain kinds of questions are more effective than others in supporting the use of learning objects (Brush & Saye, 2001).

Finally, the type of knowledge gains associated with instructional strategies need to be looked at in more detail. The results from this study suggest that certain strategies lead to significant gains in learning performance, but nothing is said about the qualitative nature of knowledge of these gains. For example, Reimer & Moyer (2005) observed increases in conceptual knowledge with learning objects, but not in procedural knowledge.

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**KEY TERMS AND DEFINITIONS**

**Design**: Layout, degree of personalization, quality of graphics, and emphasis of key concepts.

**Engagement**: Refers to difficulty level, theme, aesthetic appeal, feedback, and inclusion of multimedia.

**Engagement Construct**: Student perceptions of how engaging a learning object is.

**Interactivity**: Involves promoting constructive activity, providing a user with sufficient control, and certain degree of interaction.

**Learning Construct**: Student perceptions of how much they learned as a result of using a learning object.

**Learning Object**: Interactive Web-based tool that support the learning of specific concepts by enhancing, amplifying, and guiding the cognitive processes of learners.

**Quality Construct**: Student perceptions of the overall quality of a learning objects after they used a learning object.

**Reusability**: Permits learning objects to be useful for a large audience, particularly when the objects are placed in well organized, searchable databases.

**Self-Efficacy**: Refers to the perceived confidence that one has in doing a specific set of tasks.

**Student Performance**: The percent difference between post-test and pre-test scores.