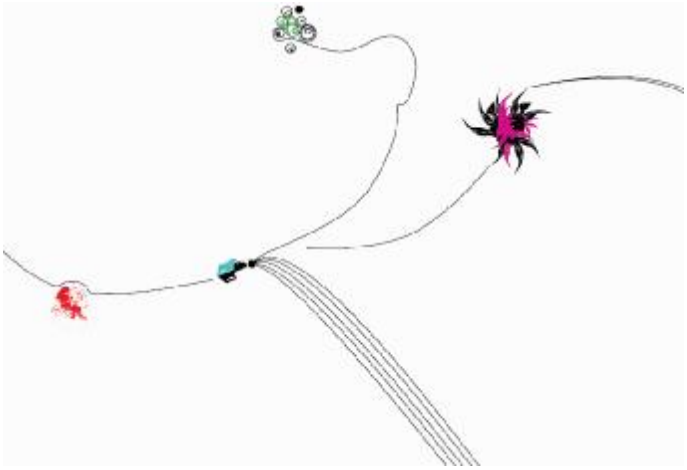
EFFECTIVITEIT VAN LEERMATERIALEN IN HET VOORTGEZET ONDERWIJS:

EEN LITERATUURSTUDIE

Joke Voogt en Natalie Pareja Roblin



UNIVERSITEIT TWENTE.

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Dit rapport is geschreven in opdracht van het Programma Leermiddelenbeleid van de VO-raad

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INHOUDSOPGAVE

HOOFDSTUK 1
INLEIDING

In dit hoofdstuk wordt de aanleiding tot en het doel van de literatuurstudie beschreven. Het hoofdstuk sluit af met een leeswijzer waarin een overzicht van het rapport wordt gegeven.

AANLEIDING VOOR HET ONDERZOEK

Uit de projecten van het Programma Leermiddelenbeleid van de VO-raad blijkt dat bij schoolleiding en docenten behoefte bestaat aan betrouwbare en praktisch toepasbare kennis op het gebied van het optimaal inzetten van digitaal leermateriaal in combinatie met papieren leermaterialen. Deze behoefte heeft zowel betrekking op onderwijskundige als schooleconomische aspecten van leermiddelenbeleid.
In deze literatuurstudie is onderzocht welke antwoorden vanuit het wetenschappelijk onderzoek kunnen worden gegeven op de vragen uit de scholen. Meer specifiek gaat deze literatuurstudie over het effectief gebruik van specifieke leermaterialen in het onderwijs. Daarbij is aandacht geschonken aan onderwijskundigen en economische aspecten van leermaterialen.

Effectief gebruik van leermaterialen kan vanuit een onderwijskundig en een schooleconomisch perspectief worden beschouwd.
Het onderwijskundig perspectief heeft betrekking op de leerfuncties waaraan het leermateriaal beoogt bij te dragen. Effectiviteit heeft in dit verband te maken met de vraag of het leermateriaal ertoe bijdraagt dat bepaalde leerfuncties op een efficiëntere of aantrekkelijkere manier kunnen worden gerealiseerd.
Het schooleconomisch perspectief heeft te maken met zowel immateriele als materiele aspecten. Effectiviteit met betrekking tot de materiele aspecten heeft betrekking op de vraag of investeringen opwegen tegen de kosten. Effectiviteit met betrekking tot de immateriële aspecten is moeilijker vast te stellen, maar hier gaat het om de ‘opbrengst’ van het gebruik van leermaterialen in relatie tot bijvoorbeeld de motivatie van leerlingen of de concurrentiepositie van de school (Moyle, 2008).

DOEL VAN HET ONDERZOEK

Het doel van de literatuurstudie is om een overzicht te geven van de stand van zaken van het onderzoek naar de effectieve inzet van diverse typen leermaterialen in het onderwijs.

De opbrengst van het literatuuronderzoek is een beschrijvende inventarisatie van nationaal en internationaal wetenschappelijk onderzoek naar effectief gebruik van digitaal en papieren leermateriaal.

ONDERZOEKSGROEP

Dit onderzoek is uitgevoerd door Joke Voogt en Natalie Pareja Roblin. Beiden werken bij de vakgroep Curriculumontwerp en Onderwijsinnovatie van de Universiteit Twente. Bij het vinden en

analyseren van de literatuur hebben zij ondersteuning gehad van Petra van Waarden, Hidde Terpoorten en Joscintha Ballast.

LEESWIJZER

In dit hoofdstuk is het onderzoek geïntroduceerd. In het volgende hoofdstuk wordt verantwoording gegeven van de gevolgde werkwijze. De resultaten van het onderzoek worden beschreven in hoofdstuk 3 en in hoofdstuk 4 worden naar aanleiding van de bevindingen conclusies getrokken.

HOOFDSTUK 2
AANPAK

Dit hoofdstuk beschrijft de strategieën en procedures die zijn gevolgd om wetenschappelijke publicaties naar het effect van leermaterialen vanuit een onderwijskundig en economische perspectief, te vinden, screenen, selecteren en analyseren.

AFBAKENING

Het belangrijkste doel van de literatuurstudie was het geven van een algemeen overzicht van de impact van diverse typen leermaterialen met betrekking tot de onderwijskundige effectiviteit en de economische aspecten gerelateerd aan het gebruik van leermaterialen in het voortgezet onderwijs. Deze studie geeft geen uitputtend overzicht van al het beschikbare onderzoek naar leermaterialen en de wijze waarop deze in het voortgezet onderwijs kunnen worden ingezet.

BRONNEN

Er is gezocht naar literatuur gepubliceerd tussen 2003 en 2009 in de twee - meest belangrijke - wetenschappelijke databases, ISI Web of Knowledge en Scopus. Daarnaast is gebruik gemaakt van rapporten van andere literatuurstudies over digitale leermaterialen (Fadel & Lemke, 2009).

ZOEKSTRATEGIE

Fase 1: Definitie van zoektermen en het toepassen van de zoekstrategie
Hieronder volgt een beschrijving van de procedure die is gevolgd om de zoektermen te definiëren voor zowel het onderwijskundige als het economische perspectief.

Onderwijskundig perspectief
Op basis van het doel van het onderzoek zijn sleutelwoorden vastgesteld: “instructional materials”, “digital materials”, “printed materials”, “learning outcomes”, “instructional effectiveness”, “secondary education”, etc.). Op basis van deze sleutelwoorden zijn met behulp van de online thesaurus van het Educational Resources Information Center (ERIC) gerelateerde termen gezocht. Om de zoekstrategie te verfijnen zijn ook termen gerelateerd aan specifieke leermaterialen gebruikt: Computerondersteund onderwijs (Computer Assisted Instruction), Drill en Practice, Tutorials, Simulaties, e-boeken (ebooks), videogames, digiborden, leerlingresponssystemen (clickers), etc.
Dit resulteerde in een lange lijst met zoektermen die op verschillende manieren zijn gecombineerd om een zo compleet mogelijk antwoord op de onderzoeksvraag te krijgen. In appendix 1 wordt een gedetailleerd overzicht van de gehanteerde zoektermen voor het onderwijskundig perspectief gegeven.
Het aantal studies dat in fase 1 werd gevonden is genoteerd. De referenties en de samenvattingen werden vervolgens geimporteerd in een database, de EndNote Library.
Economisch perspectief
Om literatuur te vinden over het economisch perspectief zijn brede zoektermen gebruikt , zoals “costs”, “return on investment”, “benefits”, “outcomes, “effectiveness” en “efficiency”, in

combinatie met algemene zoektermen die geassocieerd worden met onderwijs: “instruction”, “learning”, “learning outcomes”. De zoekstrategie werd verfijnd met termen zoals “computers”, “ICT”, “digital materials” en “e-learning” (zie appendix 2). Door vrij algemene termen te gebruiken verwachtten we een zo uitgebreid mogelijk zoekresultaat.
Met deze zoekstrategie is in de twee databases gezocht. Het aantal referenties dat met behulp van de zoekstrategie is gevonden werd genoteerd. De referenties en samenvattingen zijn vervolgens opgeslagen in de EndNote Library.

Fase 2: Selectiecriteria

Om een overzicht te krijgen van de gevonden artikelen is aan de hand van de samenvattingen van de artikelen een tabel in Excel gemaakt. In deze tabel werden de artikelen getypeerd aan de hand van de volgende aspecten:

- Onderwijsniveau
- Perspectief (economisch vs. onderwijskundig)
- Vorm van het leermateriaal (digitaal, papier)
- Korte typering van de inhoud (op grond van de samenvatting)
- Opmerkingen (eventueel)

Om te bepalen of een studie relevant was voor verdere opname in de literatuurstudie zijn de volgende criteria gebruikt:

1. Gaat de studie over voortgezet onderwijs?
2. Wordt er in de studie gerapporteerd over de onderwijskundige effectiviteit van een leermateriaal?
   In het bijzonder moesten studies die voor selectie in aanmerking kwamen, bevindingen rapporteren over tenminste één van de volgende aspecten:
   - Het effect van het leermateriaal op leeruitkomsten en / of resultaten van leerlingen.
   - Het onderwijskundig gebruik van het leermateriaal voor instructie, oefening en / of beoordeling.
   - Onderwijskundige baten van het leermateriaal (zoals motivatie, mogelijkheden voor zelfstandig werken, etc).
3. Wordt er in de studie gerapporteerd over economische aspecten van leermaterialen?
   In het bijzonder moesten studies die voor selectie in aanmerking kwamen, bevindingen rapporteren over tenminste één van de volgende aspecten:
   - Materiële en immateriële kosten gerelateerd aan het gebruik van leermaterialen.
   - Indicatoren voor kosten-baten bij het gebruik van van leermaterialen.
   - “Return on investment” van leermaterialen.

Fase 3: Definitieve selectie

Al het onderzoek dat niet duidelijk afviel op grond van de selectiecriteria werd meegenomen naar de volgende fase: het screenen van het volledige artikel. Op grond van de screening van de volledige tekst werden nog enkele studies verwijderd, omdat (a) de bevindingen bij nader inzien toch niet voldeden aan de bovengenoemde selectiecriteria, of (b) omdat de gerapporteerde resultaten te contextspecifiek waren (en niet eenvoudig overdraagbaar naar een andere context).
Alhoewel de literatuurstudie zich primair richtte op het voortgezet onderwijs zijn een paar artikelen meegenomen van studies in het hoger onderwijs, omdat deze relevant waren voor de doelen van de onderliggende studie. Dit was vooral het geval voor het economisch perspectief, omdat er geen relevant onderzoek over economische aspecten was gevonden dat betrekking had op het voortgezet onderwijs.

Naar aanleiding van de gevolgde zoekstrategie kunnen de volgende opmerkingen worden gemaakt:

- Slechts vijf studies over papieren leermaterialen voldeden aan de selectiecriteria. Van deze vijf studies, werden drie studies verwijderd na het screenen van de volledige tekst, omdat deze studies betrekking hadden op een te specifieke context en / of de ontwikkeling van een specifieke lesmethode. In de twee studies die overbleven werden papieren leermaterialen vergeleken met multimedia, waardoor de focus meer was gericht op multimedia dan op het daadwerkelijk gebruik van de papieren leermaterialen.
- Alleen studies waarvoor de volledige tekst toegankelijk was via de bibliotheek van de Universiteit Twente zijn opgenomen in de definitieve analyse.

ANALYSERAAMWERK

De artikelen zijn geanalyseerd aan de hand van een aantal aspecten, die ontleend zijn aan het doel van de studie. Hier volgt een korte beschrijving van de aspecten die zijn onderscheiden:

Onderwijskundig perspectief

Een belangrijk doel van de literatuurstudie was om een overzicht te maken van de bevindingen uit onderzoek met betrekking tot de onderwijskundige effectiviteit van verschillende leermaterialen.
Om de artikelen te typeren zijn de studies op de volgende aspecten geanalyseerd:

- Context van het onderzoek
- Kenmerken van het leermateriaal
- Typering van het instructieontwerp
- Resultaten van de studie

Deze aspecten zijn uitgewerkt in een definitief analyseraamwerk, zie hiervoor Tabel 1.

In eerste instantie was een onderscheid gemaakt tussen drie typen leermateriaal:

a. Papieren leermateriaal: Leermateriaal dat op papier beschikbaar is leermateriaal (hardcopy).
b. Digitaal leermateriaal: Leermateriaal dat beschikbaar wordt gesteld via digitale technologie, maar verder geen gebruik maak van de extra mogelijkheden die digitale technologie biedt – zoals de combinatie van tekst, audio, bewegende en statische beelden (softcopy).
c. Multimedia: Leermateriaal dat beschikbaar wordt gesteld via digitale technologie en uitdrukkelijk gebruik maakt van de extra mogelijkheden van digitale technologie.

Deze indeling bleek echter uiteindelijk niet werkbaar. In de eerste plaats omdat er weinig literatuur over uitsluitend papieren leermaterialen werd gevonden. Ook was weinig onderzoek beschikbaar (5 publicaties) naar digitaal leermateriaal dat slechts een digitale vervanging is van het papieren materiaal. De meeste studies vielken daarom onder het type multimedia, waardoor deze categorie te weinig onderscheidend was voor de verschillende ICT toepassingen die in de studies werden onderzocht.

Tabel 1 ***Analyseraamwerk onderwijskundig perspectief***

Aspect	Deelaspect	Beschrijving
Context van het onderzoek	Leeftijd leerlingen	Leeftijd van de leerlingen die aan het onderzoek hebben deelgenomen (indien genoemd).
	Leerjaar (-jaren) leerlingen	Leerjaar (-jaren) waarin het onderzoek plaatsvond (indien genoemd).
	Kenmerken leerlingen	Specialle kenmerken van leerlingen (bijv. laag / hoogpreseterend; laag / hoog gemotiveerd).
	Vak / leergebied	Natuurwetenschappen, wiskunde, moedertaal, vreemde talen, maatscahppijvakken, kunstvakken, anders.
	Doel van het onderzoek	Belangrijkste doel(en) van het onderzoek.
	Type en omvang van het onderzoek	Onderzoeksmethode (experimenteel, quasi-experimenteel, case studie etc.) en aantal deelnemers.
Leer-materiaal	Type	CAI, Multimedia, simulaties, games, MUVE, Electronische leeromgeving.
	Media	Tekst, audio, statische beelden, animatie, video.
	Modaliteit	Face-to-face, afstandonderwijs (e-learning), een combinatie van face-to-face en leren op afstand (blended leren).
Instructie-ontwerp	Setting	In de klas / school; buiten de klas / school.
	Groeperingsvorm	Hele klas, kleine groepen, individueel.
	Educatieve functie	Instructie, oefening / toepassing, evaluatie
	Didactische benadering	Instructiebenadering waarbinnen het betreffende leermiddel is ingezet (bijv. onderzoekend leren, probleemoplossend leren, directe instructie etc.)
Resultaten		Belangrijkste bevindingen van het onderzoek in termen van onderwijsopbrengsten, leerresultaten, baten, gebruik.

Er is gezocht naar een wat meer specfiekere karakterisering van de onderzochte ICT toepassingen: computerondersteund onderwijs (CAI), multimedia, simulaties, games, MUVE, Electronische leeromgeving.
Deze toepassingen zijn als volgt gedefineerd:

- ***Computerondersteund onderwijs (CAI***): drill & practice (gestructureerde oefeningen / problemen met onmiddellijke feedback) en tutorials (nieuwe informatie wordt stap voor stap geïntroduceerd en afgewisseld met testjes om na te gaan of de informatie is begrepen).
- ***Multimedia***: presenteren van informatie in een combinatie van tekst, graphics, audio en video.
- ***Simulaties***: software die de werkelijkheid imiteert. De leerling kan de situatie manipuleren om relaties in de werkelijkheid beter te begrijpen.
- ***Games***: electronisch interactief spel waarin in een spelomgeving ***(game-play)*** expliciete leerdoelen worden nagestreefd
- ***MUVE***: Een drie-dimensionale wereld met geluid en graphics in een spelomgeving,waarin leerlingen met anderen on-line interacteren.
- ***Electronische leeromgeving***: Een web-omgeving om vakken / cursussen te organiseren qua inhoud en structuur. Vaak kan lesmateriaal worden gedownload en opdrachten worden ingeleverd via de ELO[1].

[1] Een electronische leeromgeving (ELO) is strict genomen geen leermateriaal. Het was opvallend dat deze omgevingen toch uit het zoekproces kwamen en in verband werden gebracht met bepaalde uitkomsten voor het onderwijs. Daarom zijn deze toch meegenomen in de verdere analyse.

Economisch perspectief

Naast een overzicht van de bevindingen uit onderzoek met betrekking tot de onderwijskundige effectiviteit van verschillende leermaterialen, was een tweede doel van de literatuurstudie om een overzicht te maken van de kosten die geassocieerd worden met het gebruik van diverse leermaterialen in scholen. Om hierin inzicht te krijgen zijn de onderzoeken op de volgende wijze getypeerd:

- Context van het onderzoek
- Kenmerken van het leermaterialen
- Kosten
- Effectiviteit / Baten

De uitwerking van deze aspecten in een definitief analyseraamwerk wordt gepresenteerd in Tabel 2.

Tabel 2 ***Analyseraamwerk economisch perspectief***

Aspect	Deelaspect	Beschrijving
Context van het onderzoek	Leeftijd leerlingen	Leeftijd van de leerlingen die aan het onderzoek hebben deelgenomen (indien genoemd)
	Leerjaar (-jaren) leerlingen	Leerjaar (-jaren) waarin het onderzoek plaatsvond (indien genoemd)
	Kenmerken leerlingen	Specialle kenmerken van leerlingen (bijv. laag / hoogpreseterend; laag / hoog gemotiveerd)
	Doel van het onderzoek	Belangrijkste doel (-en) van het onderzoek
	Type en omvang van het onderzoek	Onderzoeksmethode (experimenteel, quasi-experimenteel, case studie etc.) en aantal deelnemers.
Leermaterialen	Type	CAI, Multimedia, simulaties, games, MUVE, Electronische leeromgeving.
	Modaliteit	Face-to-face, afstandonderwijs (e-learning), een combinatie van face-to-face en leren op afstand (blended leren)..
Kosten	Indicatoren voor kosten	Indicatoren voor materiële en immateriéle kosten geassocieerd met het gebruik van leermiddelen.
Effectiviteit / baten	Indicatoren voor effectiviteit	Indicatoren gerelateerd aan de verbetering van instructiekwaliteit, efficiëntie, management etc.

HOOFDSTUK 3
RESULTATEN

In dit hoofdstuk worden de resultaten van de literatuurstudie gepresenteerd. Eerst wordt een overzicht gegeven van de resultaten van het zoekproces. Daarna wordt per perspectief een synthese gegeven van de bevindingen.

OVERZICHT VAN DE RESULTATEN VAN HET ZOEKPROCES

Het initiële zoekproces leidde tot 167 resultaten (fase 1). Ongeveer 10% van deze studies hadden betrekking op het economische perspectief van het gebruik van leermiddelen. Na het screenen van de samenvattingen (fase 2) werden 98 studies verwijderd uit de database, omdat zij niet voldeden aan de selectiecriteria die in fase 2 waren geformuleerd (94 studies over het onderwijskundig perspectief en 4 studies over het economisch perspectief). De definitieve selectie (fase 3) resulteerde in 51 studies die nader zijn geanalyseerd.

Tabel 3 ***Zoekresultaten***

	Onderwijskundig perspectief	Economisch perspectief	Totaal
Resultaten zoekstrategie (fase 1)	151	16	167
Geselecteerde studies op basis van screening abstract (fase 2)	57	12	69
Geselecteerde studies naar het screenen van de volledige tekst (fase 3)	44	7	51

ONDERWIJSKUNDIG PERSPECTIEF

Vierenveertig van de 51 geselecteerde studies hadden betrekking op het onderwijskundig perspectief. Verreweg de meeste studies (68%) hadden betrekking op Computer Ondersteund Onderwijs (Computer Assisted Instruction (CAI)) en multimedia. Een kleiner aantal studies gingover electronische leeromgevingen, simulaties, serious games, en zogenaamde MUVEs, online spelomgevingen waarin leerlingen samenwerken met anderen aan een bepaalde uitdaging.
De meeste studies uit deze literatuurstudie hadden betrekking op de natuurwetenschappelijke vakken (27). Zeven studies gingen over wiskunde en zeven studies onderzochten het gebruik van leermaterialen in de maatschappijwetenschappelijke vakken. Vijf studies hadden betrekking op de talen en drie studies op informatica. Er moet worden opgemerkt dat in sommige studies het vakgebied niet expliciet werd genoemd, en dat is sommige studies meer dan één vak bij het onderzoek was betrokken.
De leermaterialen werden ingezet als instructiemiddel en als middel om te oefenen. In slechts één studie werd gerapporteerd over het gebruik van CAI voor de beoordeling van leerlingen,
In 28 studies wordt het leermateriaal ingezet in de face-to-face onderwijs. In 13 studies gaat het om de inzet in een e-learning context en in slechts drie studies is sprake van een combinatie van face-to-face leren en e-learning.
Hieronder volgt per leermateriaal een samenvatting van de bevindingen. De nummers verwijzen naar het artikel, waarvan de referenties en de samenvattingen in respectievelijk Appendix 3 en 5 is te vinden.

Computer Ondersteund Onderwijs (Computer Assisted Instruction (CAI))

Definitie	Drill & Practice (gestructureerde oefeningen / problemen met onmiddellijke feedback) en tutorials (nieuwe informatie wordt stap voor stap geïntroduceerd en afgewisseld met testjes om na te gaan of de informatie is begrepen).
Aantal studies	10
Vakgebieden	Diverse vakgebieden.
Groeperingsvormen	Divers. Individueel en kleine groep, nadat de stof klassikaal is ingeleid. Soms klassikaal (just-in time) gebaseerd op input over voorkennis van leerlingen (125).
Didactiek	Divers: zelfstandig leren; actief leren.
Uitkomsten	Er zijn positieve leerresultaten gevonden (21, 103, 104, 125) in vergelijking met traditioneel onderwijs. Leerlingen toonden ook een grotere betrokkenheid bij hun leerproces (21) en een positievere attitude (104). Het soort sturing (leerlinggestuurd vs programmagestuurd) hangt mede af van het type leerling: Leerlingen met voorkennis kunnen goed uit de voeten met leerlinggestuurde programma's, terwijl leerlingen met weinig voorkennis sturing door het programma nodig hebben (24). Leerlingen waarderen onmiddellijke feedback (inclusief informatie over het correcte antwoord) (148). Studies uit Taiwan laten zien dat leerlingen programmagestuurde CAI prefereren; er wordt verondersteld dat dat aan culturele factoren kan liggen (114, 115).

Multimedia

Definitie	Presenteren van informatie in een combinatie van tekst, graphics, audio en video.
Aantal studies	20
Vakgebieden	Diverse vakken.
Groeperingsvormen	Divers: Individueel & kleine groepen; soms klassikaal ingeleid met instructie of met discussie.
Didactiek	Actief leren / probleemoplossend leren.
Uitkomsten	Toename van probleemoplosvaardigheden - vooral als er hints worden gegeven (163; 164; 165; 166); toename in kennis van concepten (32, 62, 168; 116, 126, 157) en motivatie (31, 116).De combinatie van tekst en visuele beelden helpt bij het leren (44, 141), zeker als het programma de interpretatie van tekst en beelden ondersteunt (157). Het design van de multimedia doet ertoe en heeft een verschillende effect op verschillende type leerlingen: Hoogpresterende leerlingen hebben baat bij analogiën, terwijl laag presterende leerlingen voorbeelden nodig hebben (82) Laag presterende leerlingen worden ook afgeleid bij te veel plaatjes en 3D figuren (143). De positieve effecten van het leren met multimedia hangt ook af van de wijze waarop de docent het leren met multimedia inbedt in het onderwijs (22; 158; 23; 155). Ervaringen in een 1-to-1 laptop klas laten zien dat door intensieve inzet van multimediaal leermateriaal leerlingen meer tijd hebben om met de inhoud van de leerstof bezig te zijn (132).

Simulaties

Definitie	Software die de werkelijkheid imiteert. De leerling kan de situatie manipuleren om relaties in de werkelijkheid beter te begrijpen.
Aantal studies	4
Vakgebieden	Natuurwetenschappen.
Groeperingsvormen	Kleine groepen.
Didactiek	Onderzoekend leren.
Uitkomsten	De onderzoeksresultaten laten zien dat leerelingen ingewikkelde concepten beter begrijpen (47), omdat met simulaties leerlingen beter kunnen oefenenen en hun kennis kunnen articuleren (112). Leerlingen vinden zelf ook dat ze veel hebben geleerd (51). Wel is het gevaar dat leerlingen zich te veel richten op het manipuleren van variabelen, zonder zich bewust te zijn van de concepten die daaronder liggen (45).

Serious games

Definitie	Electronisch interactief spel waarin in een spelomgeving ***(game-play)*** expliciete leerdoelen worden nagestreefd.
Aantal studies	3
Vakgebieden	Informatica; Geschiedenis.
Groeperingsvormen	Individueel & kleine groepen.
Didactiek	Ontdekkend leren.
Uitkomsten	Er zijn nog weinig 'harde' onderzoeksresultaten. Leerlingen lijken meer gemotiveerd en beter geconcentreerd als ze met de game bezig zijn (28); intrinsiek gemotiveerde studenten exploreren meer dan leerlingen die niet intrinsiek gemotiveerd zijn (52). Er zijn geen verschillen gevonden in leerprestaties (28, 52) tussen leerlingen die wel en die niet met de game leren; Een gevaar kan zijn dat leerlingen het overzicht verliezen en in het spel verdwalen (159).

Multiuser Virtual Environment (MUVE)

Definitie	Een drie-dimensionale wereld met geluid en graphics in een spelomgeving,waarin leerlingen met anderen on-line interacteren.
Aantal studies	2
Vakgebieden	Talen; Science.
Groeperingsvormen	Individueel & keline groepen.
Didactiek	Probleemoplossend leren.
Uitkomsten	Er zijn nog weinig 'harde' onderzoeksresultaten. Leerlingen presteren niet beter, maar zijn wel meer gemotiveerd om te leren met behulp van de MUVE (113). De MUVE is ingebed in een les met klassikale instructie en groepsdiscussies (113). De potentie voor het leren van talen lijkt veelbelovend (126).

Electronische leeromgevingen

Definitie	Een web-omgeving om vakken/cursussen te organiseren qua inhoud en structuur. Vaak kan lesmateriaal worden gedownload en opdrachten worden ingeleverd via de ELO
Aantal studies	5
Vakgebieden	Diverse vakgebieden.
Groeperingsvormen	Divers.
Didactiek	Zelfstandig leren.
Uitkomsten	Leren kan ook buiten de klas plaatsvinden en leerlingen nemen eerder verantwoordelijkheid voor hun eigen leren (19, 6). ELO's kunnen zo worden ingezet dat de inzet past bij de wijze van lesgeven van de docent (19). Leerlingen vinden ELO's motiverend (161). Er zijn docenten en leerlingen die afwachtend zijn ten aanzien van het gebruik van ELO's in het onderwijs. (31, 111)

ECONOMISCH PERSPECTIEF

Het zoekproces heeft een beperkt aantal bronnen (7) opgeleverd die alle betrekking hebben op het hoger onderwijs. De referenties en samenvattingen zijn te vinden in respectievelijk Appendix 4 en 6. Nadere analyse wijst uit dat de meeste van deze publicaties vooral gaan over onderwijs dat volledig online is. Dat lijkt voor het voortgezet onderwijs in Nederland vooralsnog niet erg relevant. Er zijn drie artikelen gevonden die aandacht besteden aan ICT-rijk onderwijs. Laurillard (2007) en Cohen en Nachmias (2006; 2009). Deze beide artikelen worden kort samengevat vanuit het perspectief van het VO.

Cohen, A. & Nachmias, R. (2006; 2009) A quantitative cost-benefit model for web-supported academic instruction

Cohen en Nachmias bespreken de gangbare modellen om kosten en baten van ICT-rijk onderwijs te analyseren. Zij geven aan dat er overeenstemming is over de kosten die samenhangen met ICT in het onderwijs, maar niet over de baten. Cohen en Nachmias hebben een kosteneffectiviteitsmodel ontwikkeld (en beproefd op een grote Israelische universiteit), dat mathematisch is onderbouwd. Hun model richt zich op web-ondersteund onderwijs. In dergelijk onderwijs speelt het gebruik van een Electronische Leeromgeving een essentiële rol. Dergelijk ICT gebruik zien we ook steeds vaker in het VO.

Het onderliggende mathematisch model van het door Cohen en Nachmias ontwikkelde kosteneffectiviteitsmodel lijkt niet erg bruikbaar voor het VO, maar het model biedt wel inzicht in de factoren die een rol spelen bij de integratie van web-ondersteund onderwijs.

Cohen en Nachmias kwantificeren Infrastructurele kosten; Onderwijskosten en Efficiëntie (A, B en E) in geld. Verbetering van kwaliteit; affectiviteit en kennismagement (C, D en F) worden gekwantificeerd met behulp van de gegevens uit de website logs. De waarden die aan elke parameter wordt toegekend moet proefondervindelijk worden vastgesteld. Het model kan vervolgens de kosten en baten vaststellen voor de leerlingen (studenten), docenten en de insteling.

Het kosteneffectiviteitsmodel van Cohen en Nachmias

Kosten

A. Infrastructurele kosten
   - Vaste kosten: Technologische infrastructuur: hardware, software, netwerk;
   - Variabele kosten: Operationele infrastructuur: technische ondersteuning en inhoudelijke ondersteuning van de staf (docenten en ondersteunend personeel); implementatiekosten;

B. Onderwijskosten
   - Cursus-/vakontwikkeling en voorbereiding: curriculumontwikkeling; ontwikkeling van leermaterialen; aanschaf van leermaterialen;
   - Cursus- / vak: tijd nodig voor de voorbereiding, de uitvoering en de beoordeling van een vak (docenttijd);

Baten

C. Verbetering van de onderwijskwaliteit
   - Didactiek: nieuwe didactische werkvormen;
   - Inhouden: beschikbaarheid van up-to-date inhouden;
   - Interactie: toename van interactie van leerlingen met het systeem;
   - Communicatie: versterking van de interpersoonlijke communicatie;
   - Samenwerking: versterking van samenwerking;
   - Evaluatie en toetsing: Ontwikkeling van nieuwe vormen van beoordeling;
   - Feedback;

D. Verbetering van de affectieve aspecten
   - Motvatie, interesse;
   - Zelfvertrouwen met betrekking tot ICT gebruik;
   - Attitude, tevredenheid;
   - Prestige van de instelling;

E. Toegenomen efficiëntie van het onderwijsleerproces: reductie van tijd en kosten
   - Flexibiliteit: ruimte; tijd; aantal leerlingen (studenten);
   - Interactie: docent-leerling; leerling-leerling; docent/leerling – externe experts;
   - Toegankelijkheid van inhouden;
   - Beoordeling;
   - Management van het onderwijsleerproces: mededelingen; samenwerking bij de ontwikkeling van leermaterialen; electronische feedback; aanleveren en inleveren van opdrachten;

F. Verbetering van kennismanagement
   - Een portal voor alle vakken;
   - Ondersteuning van samenwerking tussen vakken;
   - Ondersteuning van samenwerking tussen docenten;
   - Inrichting van databases die beschikbaar zijn voor docenten: met het oog op kennisdeling en voor administratieve taken;
   - Hergebruik van vakken.

Laurillard, D. (2007). Modeling benefits-oriented costs for technology enhanced learning

Laurillard (2007) analyseert de beperkingen van bestaande kosten-baten modellen en stelt een nieuw model voor. Het uitgangspunt in haar model zijn de baten die ICT heeft voor het leren van leerlingen.

Laurillard besteedt geen aandacht aan de basiskosten (hardware, technische ondersteuning etc.). Dit zijn in haar opvatting de kosten die een instelling so wie so maakt, en in de meeste instituties al een vast onderdeel zijn van de begroting.

Laurrillard's model

1. Definitie van parameters die de baten definiëren in termen van 'oud'(zonder ICT) in vergelijking met 'nieuw' (met ICT): wat zijn de baten voor de lerenden.
   Welke onderwijsdoelen wil je nastreven met ICT, bijv.: differentitatie tussen leerlingen mogelijk maken; zelfstandig werken; betekenisvol leren; onderzoekend leren en welke media passen hier het best bij.
2. Definitie van parameters die de kosten definiëren die samenhangen met de in punt 1 genoemde baten; de redenering is dat de aard van de kosten samenhangt met de verwachte baten voor de lerenden.
   Dit punt operationaliseert Laurrillard op het niveau van de les.
   Verschillende media onderscheiden zich in het type leeractiviteiten die kunnen worden ondersteund. In een voorbeeld maakt Laurillard een onderscheid tussen de leeractiviteiten: kennis verzamelen, onderzoeken, disussiëren, oefenen en articuleren van kennis. Bijvoorbeeld: Kennis verzamelen en oefenen kan goed met een traditionele lesmethode en met CAI, terwijl simulaties geschikt zijn om te onderzoeken en te discussiëren.
   Vervolgens is het van belang te bepalen hoeveel tijd de docent nodig heeft om een les met het betreffende medium voor te bereiden (inhoudelijk en technisch) en uit te voeren.
3. Focus op de belangrijkste kostenpost: docenttijd; dit is wat Laurillard bereft de belangrijkste parameter!
   Dit punt operationaliseert Laurillard op het niveau van de cursus / het vak. Het gaat hier om de tijd die nodig is voor planning, ontwikkeling, ontwerp en realisatie van het vak en de daarbij benodigde ondersteuning.
4. Houd rekening met de tijd die het leerlingen kost: leerlingtijd
   Het model moet kunnen aangeven hoe de tijd van leerlingen wordt besteed als bepaalde leeractiviteiten (bijv. kennsiverzamelen, oefenen, onderzoeken etc.) door middel van verschillende media wordt gerealiseerd.
5. Zorg dat het model kan worden afgestemd op lokale condities
   De tijdsschattingen moeten lokaal worden vastgesteld en dan in het model verwerkt.
6. Maak de voordelen van ICT zichtbaar in de baten
   Een belangrijk voordeel van ICT zijn actieve werkvormen; daarnaast de mogelijkheden voor hergebruik (reductie van docenttijd in de ontwikkeling van materialen); veel ICT toepassingen hebben hoge initiële kosten, maar lage onderhoudskosten.
7. Maak de voordelen van ICT voor de verbetering van leren zichtbaar
   Laat zien wat de opbrengst is van het gebruik van ICT in termen van baten voor de lerenden (punt 1).

HOOFDSTUK 4
CONCLUSIES

De resultaten van deze literatuurstdie laten een duidelijke tendens zien voor de aandacht die er in onderzoek is naar de potentie van digitale leermaterialen voor gebruik in het voortgezet onderwijs. Het aantal studies waarin over onderzoek naar papieren leermaterialen wordt gerapporteerd is verwaarloosbaar klein ten opzichte van van het onderzoek dat wordt gedaan naar ICT toepassingen. Resultaten van wetenschappelijk onderzoek biedt weinig inzicht in de optimale inzet van digitale en papieren leermaterialen.

Terwijl het onderzoek vooral gericht is op de effectiviteit van ICT toepassingen voor het leren van leerlingen, zien we dat in praktijk van het onderwijs digitale leermaterialen nog betrekkelijk weinig worden ingezet (Voogt, 2008; OECD, 2006; Lai, 2008) en dat er zeker geen sprake is van meer geavanceerde toepassingen van ICT, zoals simulaties en serious games. Onderzoek naar het gebruik van ICT toepassingen in het onderwijs in Nederland laat bijvoorbeeld zien dat tussen 1997 en 2005 het gebruik van ICT in het onderwijs vooral beperkt was tot het gebruik van het WWW en tekstverwerken (van Kessel, Hulsen & van der Neut, 2005), in deze literatuurstudie aangeduid met de term multimedia. Becker (2000) vond hetzelfde voor de Verenigde Staten.

De potentie van ICT voor het onderwijs wordt meestal in verband gebracht met de mogelijkheden van ICT om andere didactische benaderingen te realiseren, zoals vormen van probleemoplossend en onderzoekend leren (Dede, 2000). Het gaat daarbij om onderwijs, waarin leerlingen actief betrokken zijn bij hun eigen leerproces. Het was daarom opvallend dat een relatief groot aantal studies betrekking had op onderzoek naar computerondersteund onderwijs, waarin het vaak gaat om het stapsgewijs aanbieden van gestructureerde informatie of het inoefenen van vaardigheden. Bij computerondersteund onderwijs is meestal sprake van een didactische benadering waarin overdracht van kennis en vaardigheden centraal staat. Een belangrijk kenmerk voor computerondersteund onderwijs is de mogelijkheid die ICT biedt om onderwijs te individualiseren, waardoor onderwijs op maat meer mogelijk wordt (Dede 2008).

Verreweg het meeste onderzoek dat in het kader van deze literatuurstudie werd geanalyseerd had betrekking op multimedia in het onderwijs. Dit is een brede categorie, waarin vaak gebruik wordt gemaakt van het internet om de multimedia ter beschikking te stellen aan de leerling. Multimedia kunnen zowel worden ingezet in onderwijs waarin overdracht van kennis en vaardigheden door de docent centraal staat (bijvoorbeeld bij het gebruik van een digibord) als in onderwijs waarin de leerling een actieve rol heeft (bijvoorbeeld een webquest).

Een nieuwe trend is het onderzoek naar serious games en MUVEs in het voortgezet onderwijs. Alle studies naar games en MUVEs werden in 2009 gepubliceerd. Kenmerkend voor dit type ICT toepassingen is de actieve betrokkenheid van leerlingen bij hun leeproces en de intensieve interactie met de software. Uit het onderzoek blijkt dat leerlingen gemotiveerd zijn en zich betrokken weten bij hun leerproces als ze met dit type ICT toepassingen leren. Tegelijkertijd blijkt echter dat er behoefte is aan didactische ondersteuning van docenten om leerlingen op een juiste manier te kunnen begeleiden in hun leerproces.

De resultaten van de literatuurstudie laten zien dat digitale leermaterialen in het algemeen een positief effect hebben op de leerresultaten van leerlingen. Deze bevinding wordt ondersteund door

Liao and Hao (2008) die een meta-analyse hebben uitgevoerd van studies waarin ICT-rijk onderwijs werd vergeleken met traditionele instructie in de klas. Liao en Hao vonden in hun onderzoek dat ICT-rijk onderwijs (zonder daarin onderscheid te maken tussen de diverse digitale leermaterialen) een klein maar positief effect had op de leerresulten van leerlingen. Daarbij moet worden aangemerkt dat leermaterialen die zijn ontwikkeld op grond van wetenschappelijk onderzoek een groter effect hadden op de leerresultaten dan de commerciële ICT producten.

Uit de bevindingen uit de literatuurstudie blijkt dat digitale leermaterialen een positief effect kunnen hebben op leerresultaten, motivatie van leerlingen en op het begrijpen van complexe concepten. Echter in veel van de onderzoeken die in het kader van deze literatuurstudie zijn geanalyseerd bleek dat het onderwijskundig effect van digitale leermaterialen in hoge mate afhankelijk is van:

- ***De didactische benadering.*** In bijna alle studies werd het gebruik van de leermaterialen ondersteund door actief leren, onderzoekend leren of probleemoplossend leren.
- ***Groeperingsvorm.*** In de meeste studies, waarin een positief effect van het leermateriaal op uitkomsten van onderwijs werd gevonden, werd het leermateriaal ingezet bij individuele leeracticviteiten of bij het werken in kleine groepen.
- ***Voldoende tijd***. In een aantal studies werd opgemerkt dat het gebruik van leermaterialen, zoals serious games, simulaties en MUVEs pas effect heeft als deze gedurende een langere tijd worden gebruikt. Leerlingen hebben extra tijd nodig om vertrouwd te raken met de omgeving voordat zij zich concentreren op de inhoud en de taak.
- ***Kenmerken van leerlingen***. Uit diverse studies bleek dat leerlingen, afhankelijk van hun individuele kenmerken, verschillend profiteren van leermaterialen. Zo is bijvoorbeeld geblekenn dat laagpresterende leerlingen afgeleid worden door een overvloed aan plaatjes en navigatiemogelijkheden, terwijl een dergelijke omgeving voor hoogpresterende leerlingen juist een uitdaging is.

Tot slot. Er zijn geen relevante studies gevonden die betrekking hadden op de kosten en baten van leermaterialen voor het voortgezet onderwijs. De studies die werden gevonden hadden betrekking op hoger onderwijs. De inzet van digitale leermaterialen werden daarbij vooral in verband gebracht met afstandsleren. Slechts een beperkt aantal studies had betrekking op de inzet van digitale leermaterialen in een gemixte (blended) situatie. Met name deze laatste studies kunnen ook inzicht geven in indicatoren die voor het voortgezet onderwijs van belang zijn bij de aanschaf en implementatie van digitale leermaterialen.

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APPENDIX 1
ZOEKTERMEN ONDERWIJSKUNDIG PERSPECTIEF

SECONDARY EDUCATION
Secondary Schools
High schools
Secondary school curriculum
Secondary school students
Secondary school teachers

INSTRUCTIONAL MATERIALS
Curriculum resources / Curriculum materials
Learning resources / Teaching resources
Educational resources / Educational media

PRINTED MATERIALS
Textbooks
Books
Workbooks

DIGITAL MATERIALS
Audiovisual aids / illustrations
Nonprint media
Tutorial
Drill and practice
Computer assisted learning/ computer assisted instruction
Clicker
Whiteboard

MULTIMEDIA MATERIALS
Multimedia
Hypermedia
Web based instruction
Simulation
Educational game / video game / classroom games/ serious games
Virtual reality / augmented reality

EFFICIENCY
Instructional effectiveness
Educational benefits
Instructional outcomes
Learner outcomes
Student achievement
Learning efficiency

APPENDIX 2
ZOEKTERMEN ECONOMISCH PERSPECTIEF

SECONDARY EDUCATION
Secondary Schools
High schools
Secondary school curriculum
Secondary school students
Secondary school teachers

INSTRUCTIONAL MATERIALS
Curriculum resources / Curriculum materials
Learning resources / Teaching resources
Educational resources / Educational media

TECHNOLOGY USES IN EDUCATION
Computer uses in education
Technology integration

Digital media
E-learning
Multimedia
Hypermedia

EFFICIENCY
Educational benefits
Instructional effectiveness
Instructional outcomes
Learner outcomes
Student achievement
Learning efficiency

COSTS
Cost
Benefits
Return on investment

APPENDIX 3
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APPENDIX 5
SAMENVATTINGEN VAN GEANALYSEERDE ARTIKELEN - ONDERWIJSKUNDIG PERSPECTIEF (ENGELS)

6 Mooij, T. (2004). Optimizing ICT effectiveness in instruction and learning: Multilevel transformation theory and a pilot project in secondary education. ***Computers & Education 42***(1), 25-44.

Specific combinations of educational and ICT conditions including computer use may optimize learning processes, particularly for learners at risk. This position paper asks which curricular, instructional, and ICT characteristics can be expected to optimize learning processes and outcomes, and how to best achieve this optimization. A theoretical multilevel framework is developed to specify instructional, learning, and ICT conditions that may transform and optimize both teaching and learning. The empirical part of the paper reports on and analyses a participatory, user-oriented pilot study carried out in Dutch secondary education in the period 1999-2002. The goal was to explore how teachers can develop and practice computer-supported instructional and learning processes that are qualitatively more transparent, more flexible, and more sensitive to differences between learners, than most currently prevalent teaching practices. The pilot also resulted in a multilevel software prototype LINE which was developed to support the instructional management of learners, teachers, and school management. The outcomes of the pilot study are used to specify more transformation conditions which are required within and outside schools to optimize instruction and learning in both qualitative and quantitative ways. Finally, software functions to construct more generalized 'Diagnostic, Instructional, and Management Systems' (DIMS) are modeled and discussed. (C) 2003 Elsevier Ltd. All rights reserved.

17 Angelou, G. N., & Economides, A. A. (2007). E-learning investment risk management. Information. ***Resources Management Journal, 20***(4), 80-104.

This paper describes the effects of learning support on simulation-based learning in three learning models: experiment prompting, a hypothesis menu, and step guidance. A simulation learning system was implemented based on these three models, and the differences between simulation-based learning and traditional laboratory learning were explored in the context of physics studies. The effects of the support type oil learning performance were also quantified. In second-year junior high school students it was found that the outcome for learning about the basic characteristics of an optical lens was significantly better for simulation-based learning than for laboratory learning. We also investigated the influences of different learning models on the students' abstract reasoning abilities, which showed that the different learning models do not have different effects on individuals with different abstract reasoning abilities. However, we found that students who are better at higher abstract reasoning benefit more from simulation-based learning, and also that the learning results are better for experiment prompting and a hypothesis menu than for step guidance. (C) 2008 Elsevier Ltd. All rights reserved.

19 Condie, R., & Livingston, K. (2007). Blending online learning with traditional approaches: changing practices. ***British Journal of Educational Technology, 38***(2), 337-348.

Considerable claims have been made for the development of e-learning, either as stand-alone programmes or alongside more traditional approaches to teaching and learning, for students across school and tertiary education. National initiatives have improved the position of schools in terms of access to hardware and electronic networking, software and educational resources, and staff development. The potential of e-learning to improve learning and teaching, and in turn, attainment, may be contested by academics but the policy makers arc generally positive. Many countries across Europe and North America have adopted information and communication technology (ICT) as a central plank in school improvement and effectiveness planning. At the centre, however, remain the teacher and the learner. The impact of ICT on the learning experience will depend upon the roles adopted by each, the model of the learner held by the teacher and the pedagogy adopted. This paper considers the ways in which teachers and students responded to the implementation of one particular

online programme and considers the approaches adopted and the attitudes to its use. The SCHOLAR programme is designed to complement rather than replace traditional teaching and learning approaches within schools and is aimed at students in the post-compulsory years of secondary school working towards external certification. It has a number of features including course materials, revision exercises, self-assessment facilities and a discussion forum. The independent evaluation of SCHOLAR looked at the impact that its use made on learning and teaching in the post-16 classroom and the differing ways in which teachers and students used the various elements of the programme. While it did appear to have a positive impact on attainment, the evidence indicates that this might have been greater had the teachers modified their practice, blending learning through SCHOLAR with more traditional methods.

21 Frailich, M., Kesner, M., & Hofstein, A. (2009). Enhancing students' understanding of the concept of chemical bonding by using activities provided on an interactive website. ***Journal of Research in Science Teaching, 46***(3), 289-310.

This study investigated the effectiveness of a web-based learning environment in enhancing 10th grade high-school students' understanding of the concept of chemical bonding. Two groups participated in this study: an experimental group (N = 161) and a comparison one (N = 93). The teachers in the experimental group were asked to implement four activities taken from it website, all dealing with the concept of chemical bonding. Computer-based visual models are utilized in all the activities in order to demonstrate bonding and the structure of matter, and are based on student-centered learning, The study incorporated both quantitative and qualitative research. The quantitative research consisted of achievement questionnaires administered to both the experimental and comparison groups. In contrast, the qualitative research included observations and interviews of students and teachers. Importantly, we found that the experimental group outperformed the comparison group significantly, in the achievement post-test, which examines students' understanding of the concept of chemical bonding. These results led us to conclude that the web based learning activities which integrated visualization tools with active and cooperative learning strategies provided students with opportunities to construct their knowledge regarding the concept of chemical bonding. (C) 2008 Wiley Periodicals, Inc. J Res Sci Teach 46: 289-310, 2009.

22 Hsu, Y. S. (2008). Learning about seasons in a technologically enhanced environment: The impact of teacher-guided and student-centered instructional approaches on the process of students' conceptual change. ***Science Education 92***(2), 320-344.

To explore the ways in which teacher-guided and student-centered instructional approaches influence students' conceptual understanding of seasonal change, we designed a technology-enhanced learning (TEL) course to compare, by means of concept maps, the learning outcome of students in two groups: a teacher-guided (TG) class (with whole-class presentations) and a student-centered (SC) class (with individual online learning). The participants were two classes of second-year senior high school students in Taiwan. Overall, the results showed that most students developed a deep and accessible understanding of the reasons for the seasons after undergoing experiences provided by the TEL course. More importantly, it was found that, in this technologically enhanced environment. the student-centered approach was more effective than the teacher-guided approach in altering students' alternative conceptions of seasonal change ($F=28.05$, $p < 0.001$), The conceptual evolution of students in the two groups was plotted and compared. These plots indicated that, first of all, the cognitive processes of contextualization and sense making helped students re-examine their old ideas about the phenomena, leading them to generate alternative conceptions and undergo both positive and negative conceptual change. The student-centered approach allows students to more freely test their own hypotheses in the processes of exploration and modeling, and thus move from assimilatory to properly scientific explanations. (c) 2008 Wiley Periodicals, Inc.

23 Kay, R. H., & Knaack, L. (2008). An examination of the impact of learning objects in secondary school. ***Journal of Computer Assisted Learning, 24***(6), 447-461.

Very few studies have systematically evaluated the effect of learning objects in secondary school classrooms. The vast majority of studies have focussed on higher education. The current study

examined the impact of learning objects from the perspective of 850 students and 27 teachers (50 classrooms) of science, mathematics, or social science. The results suggest that teachers typically spend 1 to 2 h finding and preparing for learning object based lesson plans that focus on the review of previous concepts. Both teachers and students are positive about the learning benefits, quality, and engagement value of learning objects, although teachers are more positive than students. Student performance increased significantly - almost 30% - when learning objects were used in conjunction with a variety of teaching strategies. It is reasonable to conclude that learning objects are a viable teaching tool in a secondary school environment.

24 Kopcha, T. J., & Sullivan, H. (2008). Learner preferences and prior knowledge in learner-controlled computer-based instruction. ***Etr&D-Educational Technology Research and Development, 56***(3), 265-286.

This study examined the effects of prior knowledge, learner preference for control, and type of control (learner or program) on the achievement of middle-school students in a computer-based instructional program on adding and subtracting integers. Students were blocked by preference-for-control scores and randomly assigned to either a learner-control or program-control version of instruction. A significant three-way interaction (prior knowledge x preference scores x type of control) revealed that students with high prior knowledge achieved better on the posttest when their preference for control was matched with the type of control they received, whereas students with low prior knowledge achieved better when their preference was mismatched. A significant three-way interaction on attitude reflected the same pattern found in the interaction for achievement scores. The overall results indicate that matching learner preference to the type of program they receive is an effective strategy for high-prior-knowledge students but not for those with low prior knowledge.

28 Papastergiou, M. (2009). Digital game-based learning in high school Computer science education: Impact on educational effectiveness and student motivation. ***Computers & Education 52***(1), 1-12.

The aim of this study was to assess the learning effectiveness and motivational appeal of a computer game for learning computer memory concepts, which was designed according to the curricular objectives and the subject matter of the Greek high school Computer Science (CS) curriculum, as compared to a similar application, encompassing identical learning objectives and content but lacking the gaming aspect. The study also investigated potential gender differences in the game's learning effectiveness and motivational appeal. The sample was 88 students, who were randomly assigned to two groups, one of which used the gaming application (Group A, N = 47) and the other one the non-gaming one (Group B, N = 41). A Computer Memory Knowledge Test (CMKT) was used as the pretest and posttest. Students were also observed during the interventions. Furthermore, after the interventions. students' views on the application they had used were elicited through a feedback questionnaire. Data analyses showed that the gaming approach was both more effective in promoting students' knowledge of computer memory concepts and more motivational than the non-gaming approach. Despite boys' greater involvement with, liking of and experience in computer gaming, and their greater initial computer memory knowledge, the learning gains that boys and girls achieved through the use of the game did not differ significantly, and the game was found to be equally motivational for boys and girls. The results suggest that within high school CS, educational computer games can be exploited as effective and motivational learning environments, regardless of students' gender, (C) 2008 Elsevier Ltd. All rights reserved.

31 Schibeci, R., Lake, D. et al. (2008). Evaluating the use of learning objects in Australian and New Zealand schools. ***Computers & Education, 50***(1), 271-283.

The Le@rning Federation, an agency funded by Australian and New Zealand governments, initiated a Field Review project as the start of a long-term research study to evaluate the impact, application and effectiveness of the online digital content developed according to the learning object model. In terms of content, the pilot Field Review found that many learning objects provided stimulating and diverse learning experiences for students. It is one of the potential strengths of learning objects that they are able to provide new geographical experiences and simulate dangerous or expensive learning activities at low relative cost. (c) 2006 Elsevier Ltd. All rights reserved.

32 Yun, R., Pan, Z., & Li, Y. (2005). ***An educational virtual environment for studying physics concept in high schools.*** Lecture Notes in Computer Science 3583, 326-331, Hong Kong.

Virtual Reality has been applied in many fields such as scientific visualization, manufacturing, architecture, entertainment, education and training. In this paper, we present a virtual educational environment for studying some abstract concept in physics. With this environment, middle school students are able to study the abstract concept such as relative motion, and to make themselves construct their knowledge of the field. Experimental results show the efficiency of our method. © Springer-Verlag Berlin Heidelberg 2005.

44 Prangsma, M. E., Van Boxtel, C. A. M., & Kanselaar, G. (2008). Developing a 'big picture': Effects of collaborative construction of multimodal representations in history. ***Instructional Science, 36***(2), 117-136.

Many pupils have difficulties with the abstract verbal information in history lessons. In this study we assessed the value of active construction of multimodal representations of historical phenomena. In an experimental study we compared the learning outcomes of pupils who co-constructed textual representations, visual-textual representations, or visual-textual representations integrated in a timeline. 85 pupils in pre-vocational secondary education, aged 12-13, worked in dyads on a series of four history tasks. All pupils took a pre-test, post-test and retention test. Results show that working on visual-textual representations integrated in a timeline leads to higher short-term results than co-constructing textual representations. Dialogue analyses for two dyads working in the condition with visual-textual representations integrated in a timeline indicate that the extent to which pupils verbally integrate textual and visual information differs for the four different tasks.

45 Rodrigues, S. (2007). Factors that influence pupil engagement with science simulations: the role of distraction, vividness, logic, instruction and prior knowledge. ***Chemistry Education and Practice, 8***(1), 1-12.

Constructivist perspectives advocate high quality visual and auditory multimedia to simulate complex and authentic situations. However, the influence of symbolic or representational learning materials on pupil engagement or learning outcomes is not clear. This paper reports on pupil engagement with two types of simulation commonly found in school science (to illustrate practical experiments or depict microscopic chemical interactions). The project pilot phase involved three 15-16 year old male pupils and a main phase involved twenty one 14-15 year old pupils. They were presented with a digital record of their 'think aloud' behaviour with the simulation and they were asked for retrospective comment. Pre and post surveys were also used. Distraction, vividness, logic, instruction and prior knowledge played a significant role in determining the nature of engagement and the outcome of engagement. E-assessment involving multimedia or symbolic representation in science education must take great care if it is to ensure that what it is assessing is the pupil's science capability and not information processing skills that rely on shared symbol identification or on the ability to follow the designers' logic of instructions.

47 Gelbart, H., Brill, G., & Yarden, A. (2009). The impact of a web-based research simulation in bioinformatics on students' understanding of genetics. ***Research in Science Education, 39***(5), 725-751.

Providing learners with opportunities to engage in activities similar to those carried out by scientists was addressed in a web-based research simulation in genetics developed for high school biology students. The research simulation enables learners to apply their genetics knowledge while giving them an opportunity to participate in an authentic genetics study using bioinformatics tools. The main purpose of the study outlined here is to examine how learning using this research simulation influences students' understanding of genetics, and how students' approaches to learning using the simulation influence their learning outcomes. Using both quantitative and qualitative procedures, we were able to show that while learning using the simulation students expanded their understanding of the relationships between molecular mechanisms and phenotype, and refined their understanding of certain genetic concepts. Two types of learners, research-oriented and task-oriented, were identified on the basis of the differences in the ways they seized opportunities to recognize the research practices, which in turn influenced their learning outcomes. The research-oriented learners expanded their genetics knowledge more than the task-oriented learners. The learning approach taken by the

research-oriented learners enabled them to recognize the epistemology that underlies authentic genetic research, while the task-oriented learners referred to the research simulation as a set of simple procedural tasks. Thus, task-oriented learners should be encouraged by their teachers to cope with the scientists' steps, while learning genetics through the simulation in a class setting.

51 Klopfer, E., Yoon, S., & Rivas, L. (2004). Comparative analysis of Palm and wearable computers for Participatory Simulations. ***Journal of Computer Assisted Learning, 20***(5), 347-359.

Recent educational computer-based technologies have offered promising lines of research that promote social constructivist learning goals, develop skills required to operate in a knowledge-based economy (Roschelle et al. 2000), and enable more authentic science-like problem-solving. In our research programme, we have been interested in combining these aims for curricular reform in school science by developing innovative and progressive hand-held and wearable computational learning tools. This paper reports on one such line of research in which the learning outcomes of two distinct technological platforms (wearable computers and Palm hand-helds) are compared using the same pedagogical strategy of Participatory Simulations. Participatory Simulations use small wearable or hand-held computers to engage participants in simulations that enable inquiry and experimentation (Colella 2000) allowing students to act out the simulation themselves.
The study showed that the newer and more easily distributable version of Participatory Simulations on Palms was equally as capable as the original Tag-based simulations in engaging students collaboratively in a complex problem-solving task. We feel that this robust and inexpensive technology holds great promise for promoting collaborative learning as teachers struggle to find authentic ways to integrate technology into the classroom in addition to engaging and motivating students to learn science.

52 Martens, R. L., Gulikers, J., & Bastiaens, T. (2004). The impact of intrinsic motivation on e-learning in authentic computer tasks. ***Journal of Computer Assisted Learning, 20***(5), 368-376.

Students with high intrinsic motivation often outperform students with low intrinsic motivation. However, little is known about the processes that lead to these differences. In education based on simulations or authentic electronic learning environments, this lack of insight is even more clear. The present study investigated what students actually did in an electronic learning environment that was designed as a game-like realistic simulation in which students had to play the role of a junior consultant. The results show that students with high intrinsic motivation did not do more, rather they tended to do different things. Analysis of log files showed that the increased curiosity that students with high intrinsic motivation have, resulted in proportionally more explorative study behaviour. However, the learning outcomes of students with high intrinsic motivation were not better.

62 Nokes, J. D., Dole, J. A., & Hacker, D. J. (2007). Teaching high school students to use heuristics while reading historical texts. ***Journal of Educational Psychology, 99***(3), 492-504.

The purpose of this study was to test the effectiveness of different types of instruction and texts on high schools students' learning of (a) history content and (b) a set of heuristics that historians use to think critically about texts. Participants for the study were 128 male and 118 female students, ages 16 and 17 years, from 2 high schools in the western United States. Eight history classrooms were randomly assigned to 1 of 4 interventions: (a) traditional textbooks and content instruction, (b) traditional textbooks and heuristic instruction, (c) multiple texts and content instruction, or (d) multiple texts and heuristic instruction. The heuristic instruction explicitly taught sourcing, corroboration, and contextualization. Students were administered pretests on their content knowledge and their use of heuristics. After an intervention of 3 weeks, students were readministered the content knowledge and heuristics posttests. A mixed-model analysis of covariance indicated that across all conditions, students who read multiple texts scored higher on history content and used sourcing and corroboration more often than students who read traditional textbook material. Findings highlight the importance of reading multiple texts to deepen content knowledge and facilitate the use of heuristics that historians typically use.

82 Luik, P., & Mikk, J. (2008). What is important in electronic textbooks for students of different achievement levels? ***Computers & Education, 50***(4), 1483-1494.

This paper reports the findings of a study that explored which characteristics of electronic textbooks correlated with knowledge acquisition by learners of different achievement levels. The study was carried out on 35 units of electronic textbooks that were studied by 19 high-achieving and 19 low-achieving students in four Estonian schools. The low-achieving students profited from clear instructions, familiar icons, examples, and answering from the keyboard. The high-achieving students benefited from key-combinations, menus with different levels, the Internet, analogies and lower density of terms in the content of the material. In electronic textbooks, not only the content, but also the design of the software, should be different for learners with a different achievement level.

103 Hu, P. J. H., W. Hui, et al. (2007). Technology-assisted learning and learning style: A longitudinal field experiment. ***IEEE Transactions on Systems, Man, and Cybernetics Part A: Systems and Humans, 37***(6), 1099-1112.

From a student's perspective, technology-assisted learning provides convenient access to interactive contents in a hyperlinked multimedia environment that allows increased control over the pace and timing of the presented material. Previous research examining different aspects of technology-assisted learning has found equivocal results concerning its effectiveness and outcomes. We extend prior studies by conducting a longitudinal field experiment to compare technology-assisted with face-to-face learning for students' learning of English. Our comparative investigation focuses on learning effectiveness, perceived course learnability, learning-community support, and learning satisfaction. In addition, we analyze the effects of different learning styles in moderating the effectiveness of and satisfaction with technology-assisted learning. Overall, our results show significantly greater learning effectiveness with technology-assisted learning than with conventional face-to-face learning. Learning style has noticeable influences on the effectiveness and outcomes of technology-assisted learning. We also observe an apparently important interaction effect with the medium for delivery, which may partially explain the equivocal results of previous research.

104 Aivazidis, C., Lazaridou, M. et al. (2006). A comparison between a traditional and an online environmental educational program. ***Journal of Environmental Education***, ***37***(4), 45-54.

The authors compared traditional and Web-based versions of an environmental education program in terms of their effectiveness in raising knowledge and promoting attitudes of environmental issues. They used a pretest-posttest nonequivalent control group quasi-experimental design. Results showed a statistically significant increase of knowledge scores for both groups. The junior high students who received computer-assisted instruction (CAI) significantly outscored their peers who were taught traditionally in posttest knowledge scores. In addition, the CAI group demonstrated a significant increase in attitudes scores. The authors found the correlation coefficient between knowledge and attitudes to be statistically significant but low.

111 Yang, F. Y. & Chang, C. C. (2009). Examining high-school students' preferences toward learning environments, personal beliefs and concept learning in web-based contexts. ***Computers & Education, 52***(4), 848-857.

The purpose of the study is to explore three kinds of personal affective traits among high-school students and their effects on web-based concept learning. The affective traits include personal preferences about web-based learning environments, personal epistemological beliefs, and beliefs about web-based learning. One hundred 11th graders participated in the study. Three questionnaires were developed to assess these affective characteristics. An online test and the flow-map technique were employed to probe concept achievements that indicated the learning outcome. Descriptive statistics, t-tests, correlation and regression analyses were conducted to present trends and relations among variables. It was found that participants of the study who mostly had not developed sophisticated epistemological beliefs displayed only moderate preferences toward explorative and interactive web-based learning environments, and they seemed to be conservative about the

effectiveness of the new type of learning. According to the flow-map technique, the serial form of concept achievements was the main product of concept learning in the explorative web-based environments defined in the study. Regression analyses indicated that while preferences toward inquiry-based instructional designs and outward interactions, and the simple form of personal epistemology predicted concept achievements, beliefs about effectiveness of web-based learning resulted in a negative impact on concept learning. (C) 2008 Elsevier Ltd. All rights reserved.

112 Soderberg, P., & Price, F. (2003). An examination of problem-based teaching and learning in population genetics and evolution using EVOLVE, a computer simulation. ***International Journal of Science Education,*** 25(1), 35-55.

This study describes a lesson in which students engaged in inquiry in evolutionary biology in order to develop a better understanding of the concepts and reasoning skills necessary to support knowledge claims about changes in the genetic structure of populations, also known as microevolution. This paper describes how a software simulation called EVOLVE can be used to foster discussions about the conceptual knowledge used by advanced secondary or introductory college students when investigating the effects of natural selection on hypothetical populations over time. An experienced professor's use and rationale of a problem-based lesson using the simulation is examined. Examples of student misconceptions and naive (incomplete) conceptions are described and an analysis of the procedural knowledge for experimenting with the computer model is provided. The results of this case study provide a model of how EVOLVE can be used to engage students in a complex problem-solving experience that encourages student meta-cognitive reflection about their understanding of evolution at the population level. Implications for teaching are provided and ways to improve student learning and problem solving in population genetics are suggested.

113 Annetta, L. A., Minogue, J., Holmes, S. Y., et al. (2009). Investigating the impact of video games on high school students' engagement and learning about genetics. ***Computers & Education, 53***(1), 74-85.

The popularity of video games has transcended entertainment crossing into the world of education. While the literature base on educational gaming is growing, there is still a lack of systematic study of this emerging technology's efficacy. This quasi-experimental study evaluated a teacher created video game on genetics in terms of its affective and cognitive impact on student users. While statistical results indicated no differences ($p > .05$)in student learning as measured by our instrument, there were significant differences ($p < .05$) found in the participants' level of engagement while interfacing with the video game. Implications on this emerging line of inquiry re discussed. (C) 2009 Elsevier Ltd. All rights reserved.

114 Chang, C. Y. (2003). Teaching earth sciences: should we implement teacher-directed or student-controlled CAI in the secondary classroom? ***International Journal of Science Education, 25***(4), 427-438.

While previous studies and meta analyses have primarily focused on the comparative efficacy of computer assisted instruction (CAI) versus traditional instruction, there have been relatively fewer examples of research exploring how various teaching formats of CAI influence student science learning outcomes in the secondary classroom. In this paper this issue is addressed by comparing teacher-directed CAI (TDCAI) and student-controlled CAI (SCCAI) in a compulsory earth science course in a secondary school in Taiwan. Data collection instruments included the Earth Science Achievement Test and the Attitudes Toward Earth Science Inventory. A multivariate analysis of covariance suggested that TDCAI students had significantly higher score gains than SCCAI students on the set of achievement and attitude measures. It is therefore suggested that TDCAI-based instruction is an alternative in teaching basic science concepts in the secondary classroom.

115 Chang, C. Y., & Tsai, C. C. (2005). The interplay between different forms of CAI and students' preferences of learning environment in the secondary science class. ***Science Education, 89***(5), 707-724.

This evaluation study investigated the effects of a teacher-centered versus student-centered computer-assisted instruction (CAI) on 10th graders' earth science student learning outcomes. This study also explored whether the effects of different forms of computer-assisted instruction (CAI) on student

learning outcomes were influenced by student preferences of learning environment (PLE). A total of 347 10th-grade senior high school students participated in this nonequivalent control group quasiexperiment. During a one-week period, one group of students (n = 216) were taught by a teacher-centered CAI (TCCAI) model whereas the other group of students (n = 131) were subject to a student-centered CAI (SCCAI) method. Results showed that (a) no statistically significant difference on students' earth science achievement was found for either group; (b) TCCAI, group had significantly better attitudes toward earth science than did the SCCAI group; furthermore (c) a significant PLE-treatment interaction was found on student attitudes toward the subject matter, where the teacher-centered instructional approach seemed to enhance more positive attitudes of less constructivist-oriented learning preferences students, whereas the student-centered method was more beneficial to more constructivist-oriented learning preferences students on their attitudes toward earth science in a computer-assisted learning environment.

116 Chang, C. Y. (2004). Could a laptop computer plus the liquid crystal display projector amount to improved multimedia geoscience instruction? ***Journal of Computer Assisted Learning, 20***(1), 4-10.

In this study, a multimedia computer-aided tutorial (MCAT) on the topic of debris-flow hazards was developed for senior high-school students in Taiwan. The format of the new course is a blend of whole-class presentations, interactive discussions among the teacher and students, and classroom activities using the MCAT software. The whole-class presentation was presented using both a laptop computer and a high-resolution liquid crystal display projector to display the MCAT contents on a large white screen in front of a whole class. Besides, class discussions between the teacher and the students and among students were also embedded in the teaching format. Students' earth science learning outcomes were evaluated by administering an achievement test and a survey of attitudes towards the earth science subject before and after the course. The results indicated that MCAT accompanied by the current 'interactive whole-class teaching' form could significantly help the students' grasp of earth science concepts and greatly improve their attitudes towards earth science.

125 Benedict, J. O., & Anderton, J. B. (2004). Applying the just-in-time teaching approach to teaching statistics. ***Teaching of Psychology, 31***(3), 197-199.

Just-in-Time Teaching (JiTT) is a Web-based teaching strategy that prepares both the student and the teacher for a more meaningful and engaging classroom encounter. We used this approach to teach statistics. When compared to an equivalent class based on content and textbook, the students in the JiTT class performed better on the final exam and expressed satisfaction with the approach. This study suggested the success of combining principles of active learning and Web-based technology.

126 Porter, S. G., Day, J., McCarty, R. E., Shearn, A., Shingles, R., Fletcher, L., et al. (2007). ***Exploring DNA structure with Cn3D***. CBE Life Sci Educ, 6(1), 65-73.

Researchers in the field of bioinformatics have developed a number of analytical programs and databases that are increasingly important for advancing biological research. Because bioinformatics programs are used to analyze, visualize, and/or compare biological data, it is likely that the use of these programs will have a positive impact on biology education. Over the past years, we have been working to help biology instructors introduce bioinformatics activities into their curricula by providing them with instructional materials that use bioinformatics programs and databases as educational tools. In this study, we measured the impact of a set of these materials on student learning. The activities in these materials asked students to use the molecular structure visualization program Cn3D to locate, identify, or analyze diverse features in DNA structures. Both the experimental groups of college and high school students showed significant increases in learning relative to control groups. Further, learning gains by the college students were correlated with the number of activities assigned. We conclude that working with Cn3D was important for improving student understanding of DNA structure. This study is one example of how a bioinformatics program for visualization can be used to support student learning.

131 Lennon, J., & Maurer, H. (2003). Why it is difficult to introduce e-learning into schools and some new solutions. ***Journal of Universal Computer Science, 9***(10), 1244-1257.

Most informed educators agree that e-Learning should create a paradigm shift away from traditional teaching models, yet in practice this is extremely difficult to achieve. Typically, teachers use computer networks (internet or intranets) mainly for email, dissemination of information that frequently just mirrors traditional book material, assignments, and perhaps a discussion forum. In this paper, we examine reasons why there has been so little departure away from conventional teaching paradigms. We look beyond Virtual Learning Environments to Managed Learning Environments. We look at ways to make this transition a desirable option for both teachers and students. We suggest that when teachers and learners are properly supported within a Managed Learning Environment the workload of teachers is not increased and they enjoy teaching more; also, students learn better (i.e. more efficiently) and with higher motivation.

132 Zucker, A. A., & Hug, S. T. (2008). Teaching and learning physics in a 1:1 Laptop School. ***Journal of Science Education and Technology, 17***(6), 586-594.

1:1 laptop programs, in which every student is provided with a personal computer to use during the school year, permit increased and routine use of powerful, user-friendly computer-based tools. Growing numbers of 1:1 programs are reshaping the roles of teachers and learners in science classrooms. At the Denver School of Science and Technology, a public charter high school where a large percentage of students come from low-income families, 1:1 laptops are used often by teachers and students. This article describes the school's use of laptops, the Internet, and related digital tools, especially for teaching and learning physics. The data are from teacher and student surveys, interviews, classroom observations, and document analyses. Physics students and teachers use an interactive digital textbook; Internet-based simulations (some developed by a Nobel Prize winner); word processors; digital drop boxes; email; formative electronic assessments; computer-based and stand-alone graphing calculators; probes and associated software; and digital video cameras to explore hypotheses, collaborate, engage in scientific inquiry, and to identify strengths and weaknesses of students' understanding of physics. Technology provides students at DSST with high-quality tools to explore scientific concepts and the experiences of teachers and students illustrate effective uses of digital technology for high school physics.

141 Mayer, R. (2003). The promise of multimedia learning: using the same instructional design methods across different media. ***Learning and Instruction, 13,*** 125–139.

Multimedia learning occurs when students build mental representations from words and pictures that are presented to them (e.g., printed text and illustrations or narration and animation). The promise of multimedia learning is that students can learn more deeply from well-designed multimedia messages consisting of words and pictures than from more traditional modes of communication involving words alone. This article explores a program of research aimed at determining (a) research-based principles for the design of multimedia explanations-which can be called methods, and (b) the extent to which methods are effective across different learning environments-which can be called media. A review of research on the design of multimedia explanations conducted in our lab at Santa Barbara shows (a) a multimedia effect-in which students learn more deeply from words and pictures than from words alone-in both book-based and computer-based environments, (b) a coherence effect-in which students learn more deeply when extraneous material is excluded rather than included-in both book-based and computer-based environments, (c) a spatial contiguity effect-in which students learn more deeply when printed words are placed near rather than far from corresponding pictures-in both book-based and computer-based environments, and (d) a personalization effect-in which students learn more deeply when words are presented in conversational rather than formal style-both in computer-based environments containing spoken words and those using printed words. Overall, our results provide four examples in which the same instructional design methods are effective across different media.

143 Korakakis, G., Pavlatou, E.A., Palyvos, J.A., & Spyrellis, N. (2009). 3D visualization types in multimedia applications for science learning: A case study for 8th grade students in Greece. ***Computers & Education, 52,*** 390-40.

This research aims to determine whether the use of specific types of visualization (3D illustration, 3D animation, and interactive 3D animation) combined with narration and text, contributes to the learning process of 13- and 14- years-old students in science courses. The results indicate that multimedia applications with interactive 3D animations as well as with 3D animations do in fact increase the interest of students and make the material more appealing to them. The findings also suggest that the most obvious and essential benefit of static visuals (3D illustrations) is that they leave the time control of learning to the students and decrease the cognitive load.

147 Alty, J.L., Al-Sharrah, A., & Beacham, N. (2006). When humans form media and media form humans: An experimental study examining the effects different digital media have on the learning outcomes of students who have different learning styles. ***Interacting with Computers, 18***, 891–909.

A set of computer-based experiments are reported that investigate the understanding achieved by learners when studying a complex domain (statistics) in a real e-learning environment using three different media combinations-Text only, Text and Diagrams and Spoken Text and Diagrams, and the results agree with earlier work carried out on more limited domains. The work is then extended to examine how student interaction and student learning styles affect the learning outcomes. Different responses to the media combinations are observed and significant differences occur between learners classified as Sensing and Reflective learners. The experiment also identified some important differences in performance with the different media combinations by students registered as Dyslexic. The experiment was therefore repeated with a much larger sample of Dyslexic learners and the earlier effects were found to be significant. The results were surprising and may provide useful guidance for the design of material for Dyslexic students.

148 Karadeniz, S. (2009). The impacts of paper, web and mobile based assessment on students' achievement and perceptions. ***Scientific Research and Essay***, ***4***(10), 984-99.

The aim of this study was to determine the impacts of paper based, web based and mobile based assessment on the achievement of the students in the internet assisted instruction. A further investigation was also performed to find out perceptions of the students on the delivery mode of the assessment. 2*3 factorial design was used in the study. Thirty eight students who formed experimental and control group, attended the study for 3 weeks. The findings of the study revealed that there was no significant difference between the achievement level of the students who took paper, web and mobile based assessment and the students who took only paper based test. However, a significant difference was found between the scores of the test taken in the second week and those of the others. Finally, it was found that students had positive perceptions on web and mobile based test due to the ease of use, comprehensive and instant feedback. Besides, the most favored test was web based test and the least favored test was paper based test.

155 Richards, C. (2005). The Design of Effective ICT-Supported Learning Activities: Exemplary Models, Changing Requirements, and New Possibilities. ***Language Learning & Technology, Volume 9 (1),*** pp. 60-79.

Despite the imperatives of policy and rhetoric about their integration in formal education, Information and Communication Technologies (ICTs) are often used as an "add-on" in many classrooms and in many lesson plans. Nevertheless, many teachers find that interesting and well-planned tasks, projects, and resources provide a key to harnessing the educational potential of digital resources, Internet communications, and interactive multimedia to engage the interest, interaction, and knowledge construction of young learners. To the extent that such approaches go beyond and transform traditional "transmission" models of teaching and formal lesson planning, this paper investigates the changing requirements and new possibilities represented by the challenge of integrating ICTs in education in a way which at the same time connects more effectively with both the specific contents of the curriculum and the various stages and elements of the learning process. Case studies from teacher

education foundation courses provide an exemplary focus of inquiry in order to better link relevant new theories or models of learning with practice, to build upon related learner-centered strategies for integrating ICT resources and tools, and to incorporate interdependent functions of learning as information access, communication, and applied interactions. As one possible strategy in this direction, the concept of an "ICT-supported learning activity" suggests the need for teachers to approach this increasing challenge more as "designers" of effective and integrated learning rather than mere "transmitters" of skills or information through an add-on use of ICTs.

157 Lo, J.-J., Chang, C.-J., Tu, H.-H., & Yeh, S.-W. (2009). Applying GIS to develop a web-based spatial-person-temporal history educational system. ***Computers & Education, 53***(1), 155-168.

Developing interactive history learning materials to facilitate historical thinking is one of the challenges in history teaching and learning. This study developed a web-based history educational system, which has used the acronym HES-SPATO (history educational system based on SPATO), to increase the understandability of history learning materials. SPATO (spatial, person, action/attribute, and temporal object) was designed to integrate the indispensable elements of history events such as space, person, action/attribute, and time. HES-SPATO also applied temporal logic to reason the temporal relationships between history events. Furthermore, it employed the GIS concept of information layers to develop the student interface. The findings of the experiments indicated that the use of HES-SPATO was effective in enhancing students' history learning. The participants also showed positive attitudes toward the HES-SPATO system in terms of the perceived ease of use, perceived usefulness, attitude to use, intention to use, recall of web sites, and perceived usefulness of assistant tools. Although many functionalities have been added to the HES-SPATO system, there was no significant difference in system efficiency between HES-SPATO and the comparative system. These experimental results also guide the direction of future research.

158 Greene, J.A., Bolick, C.M., & Robertson, J. (2010). Fostering historical knowledge and thinking skills using hypermedia learning environments: The role of self-regulated learning. ***Computers & Education***, ***54***(1), 230-243.

In this study, we examined how high-school students utilized a hypermedia learning environment (HLE) to acquire declarative knowledge of a historical topic, as well as historical thinking skills. In particular, we were interested in whether self-regulated learning (SRL; Winne & Hadwin, 1998; Zimmerman, 2000) processing was related to the acquisition of declarative knowledge and historical thinking. We found that, using the HLE, participants did learn from pretest to posttest, and that they most often engaged in strategy use SRL processes. However, the frequency of participant use of planning SRL processes, not strategy use, was predictive of learning. This study has implications for how educators use HLEs to foster historical thinking skills, and suggests that scaffolding planning skills may facilitate students' use of computers as cognitive and metacognitive tools for learning (Azevedo, 2005; Lajoie, 2000).

159 Akkerman, S.; Admiraal, W.; Huizenga, J. (2009). Storification in History education: A mobile game in and about medieval Amsterdam. ***Computers & Education, 52***(2), 449-459.

A mobile and multimedia game designed for History education was analyzed in terms of how it is designed and how it was applied as a narrative learning environment. In History education, narrative can be argued to be very useful to overcome fragmentation of the knowledge of historical characters and events, by relating these with meaningful connections of temporality and sequence (storification). In the game studied, students explore the history of Amsterdam by walking in the city, experiencing characters, buildings, and events, while using UMTS/GPS phones for communication and exchange of information. The History game was played during one day by 216 students, spread over 10 secondary school classes, in groups of four or five students. All information exchanged during the games was collected, and the game play and introduction of the game was observed by team coaches and researchers. The design of the game as well as the actual gaming process was analyzed with respect to how it evoked three types of storification: receiving (spectator), constructing (director) and participating in (actor) the story. Results show that the game evoked a mixture of these three types of storification. Moreover, these types of storification processes differently affected students'

engagement. Participating in the story evoked high activity in the game but less awareness of the whole story, whereas constructing the story triggered awareness of the whole story. Compared to receiving the story, both these types positively affected the engagement of the students being active and motivated during the game. (C) 2008 Elsevier Ltd. All rights reserved.

161 Yang, S.C. & Chen, Y.J. (2007). Technology-enhanced language learning: A case study. ***Computers in Human Behavior, 23***(1), 860-879.

This study explores participant views regarding the integration of Internet tools in language learning activities. The descriptive study has illustrated the perceptions of a class of senior high school students regarding language learning in a technology environment. The subjects were 44 10th-grade male students and their teacher who together joined a technology-enhanced language learning (TELL) project in Taiwan known as "Advanced Joint English Teaching" (AJET). The students participated in six Internet-based teaching activities; group e-mailing, a Web-based course, an e-mail writing program, English homepage design, video-conferencing and chat room discussion. This study found that the AJET project provided the students with an opportunity to experience new technologies; learners experienced the pleasure of learning and thus increased their learning possibilities. The students liked and approved of teaming English using the Internet, but had differing opinions about its benefits. The study demonstrated that learners bring different perspectives to TELL, and that learners who are passively oriented towards Internet English learning require careful guidance from pedagogical applications to this approach. Making students aware that learning English through multimedia technology demands new learning strategies and self-directed learning is a crucial first step. Some pedagogical suggestions are provided for effectively using computer networking in second- and foreign language classrooms. (c) 2006 Elsevier Ltd. All rights reserved.

162 Karasavvidis, I., Pieters, J.M., & Plomp, T. (2003). Exploring the mechanisms through which computers contribute to learning. ***Journal of Computer Assisted Learning, 19***(1), 115-128.

Even though it has been established that the incorporation of computers into the teaching and learning process enhances student performance, the underlying mechanisms through which this is accomplished have been largely unexplored. The present study aims to shed light on this issue. Two groups of 10 secondary school students were tutored by their geography teacher in how to solve correlational problems. Students in the one group used paper and pencil while students in the other group used a computer spreadsheet. All tutorials were videotaped, transcribed verbatim, and subsequently all transcripts were segmented and coded. The mean frequencies for teacher and student behaviours between the two conditions were then compared. Results indicated that teacher behaviour in the two conditions differed in terms of error feedback, factual and conceptual questions asked, regulation of students, and task management. Regarding student behaviours, the findings showed that the two conditions differed in terms of task engagement, goal setting, and explanations given. On the basis of these findings the issue of mechanisms is discussed and three main implications for the teaching and learning practice are drawn.

163 Pol, H. J., Harskamp, E. G., Suhre C. J. M. & Goedhart, M. J. (2009). How indirect supportive digital help during and after solving physics problems can improve problem-solving abilities. ***Computers & Education, 53***, 34-50.

This study investigates the effectiveness of computer-delivered hints in relation to problem-solving abilities in two alternative indirect instruction schemes. In one instruction scheme, hints are available to students immediately after they are given a new problem to solve as well as after they have completed the problem. In the other scheme, hints are only available as worked out problems after students have finished their solution. The instruction schemes are supplied by means of a web-based program, Physhint, which supports the development of strategic knowledge [Pol, H. J., Harskamp, E. G., & Suhre, C. J. M. (2008). The effect of the timing of instructional support in a computer-supported problem-solving program for students in secondary physics education. Computers in Human Behavior, 24, 1156-1178]. This program supports novice problem solvers while undertaking physics problems concerned with forces by providing hints structured in accordance with Schoenfeld's episodes [Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition,

and sense making in mathematics. In D. A. Grouws (Ed.), Handbook of research on mathematics teaching (pp. 224-270). New York: McMillan Publishing]. An experiment was carried out in four schools in order to study students' use of the hints in both of the computerized instruction schemes, as well as the effect of different uses of the available hints on students' ability to solve physics problems. The experiment consisted of three groups. Two groups of students were assigned to one of the two instruction schemes and a control group was selected for the purpose of comparison. The results of the experiment show that both computerized instruction schemes are effective. Students working with the most elaborate instruction scheme show an increased use of their pallet of heuristics and algorithms in the post-test. Furthermore, the instruction scheme in which hints are available to students during problem-solving proves to be most effective when students show an increase in the systematic use of hints during problem-solving. This paper therefore provides an insight into how a computer program implemented in school practice can improve students' strategic knowledge.

164 Pol, H. J., Harskamp, E. G., Suhre C. J. M., & Goedhart, M. J. (2008). The effect of hints and nodel answers in a student-controlled problem-solving Program for secondary physics education. ***Journal of Science Education and Technology, 17***, 410-425.

Many students experience difficulties in solving applied physics problems. Most programs that want students to improve problem-solving skills are concerned with the development of content knowledge. Physhint is an example of a student-controlled computer program that supports students in developing their strategic knowledge in combination with support at the level of content knowledge. The program allows students to ask for hints related to the episodes involved in solving a problem. The main question to be answered in this article is whether the program succeeds in improving strategic knowledge by allowing for more effective practice time for the student (practice effect) and/or by focusing on the systematic use of the available help (systematic hint-use effect). Analysis of qualitative data from an experimental study conducted previously show that both the expected effectiveness of practice and the systematic use of episode-related hints account for the enhanced problem-solving skills of students.

165 Pol, H. J., Harskamp, E. G., & Suhre, C. J. M. (2008). The effect of the timing of instructional support in a computer-supported problem-solving program for students in secondary physics education. ***Computers in Human Behavior***, ***24***, 1156-1178.

Many students experience difficulties in solving applied physics problems. Researchers claim that the development of strategic knowledge (analyze, explore, plan, implement, verify) is just as necessary for solving problems as the development of content knowledge. In order to improve these problem-solving skills, it might be profitable to know at what time during problem solving is the use of instructional support most effective: before, during or after problem solving. In an experiment with fifth-year secondary school students, one experimental group (n = 18) received hints during and worked examples after problem solving, and another experimental group (n = 18) received worked examples only after problem solving. Both groups used versions of a computer program to solve a variety of problems. The control group (n = 23) used a textbook. There was a pre-test to estimate the measure of prior expertise of the students in solving physics problems. The results of a problem-solving post-test indicated that the version of the program providing hints during and examples after problem solving was the most effective, followed by the version which only supplied examples afterwards. There was no difference in effect for students with more than average prior knowledge or less prior knowledge.

166 Pol, H., Harskamp, E., & Suhre, C. (2005). The solving of physics problems: computer assisted instruction. ***International Journal of Science Education, 27***, 451-469.

The main goal of most physics textbooks is to develop declarative and procedural knowledge. Exercises provide pupils with opportunities to apply this knowledge. However, when confronted with more complicated exercises many pupils experience difficulties in solving them. A computer program about the subject of forces was developed containing hints for the various different episodes of problem-solving. A study was undertaken with a group taking part in the experiment (n = 11) who used both

their textbook and the computer program, and a control group (n = 25) who used their textbook only. There was evidence to show that the pupils from the group taking part in the experiment did achieve higher results in solving problems. Exploration and planning were improved but evaluation was not. It appeared that pupils involved in the experiment made better use of their declarative knowledge in solving problems than pupils from the control group.

APPENDIX 6
SAMENVATTINGEN VAN GEANALYSEERDE ARTIKELEN – ECONOMISCH PERSPECTIEF (ENGELS)

1 Bishop, T. M. (2007). The return on investment in online education. ***Journal of Veterinary Medical Education, 34***(3): 257-262.

In the decade since online education emerged in higher education, digital learning has become increasingly commonplace. Various models exist-from those offered fully online to others that combine traditional classroom time with some online activities. This article identifies the dominant emergent models, provides examples of their Implementation across higher-education institutions, and evaluates the cost analyses conducted to date on this relatively new teaching and learning model. The ways In which we determine the return on investment depend upon the cost indicators selected, the measures of effectiveness used, and the indices by which institutions mark progress toward their educational and cost objectives. © 2007 AAVMC.

2 Yi, L.-Y., Zuo, M.-Z., & Wang, Z.-X. (2007). ***A model for analyzing and evaluating the return on investment in e-learning***. ***Proceedings - The 7th IEEE International Conference on Advanced Learning Technologies, ICALT 2007***, art. no. 4280955, 79-81.

As investment in e-learning accelerates rapidly worldwide, it is important to improve the economic performance in the existing e-learning initiatives. This article presents a model for analyzing and evaluating the return on investment (ROI) in e-learning. The article also explains each component of the model in details. The model highlights the important issues that must be addressed to optimize the investment strategy. The model also further identifies the return on the investment by the mathematical method of fuzzy comprehensive evaluation. © 2007 IEEE.

3 Laurillard, D. (2007). Modelling benefits-oriented costs for technology enhanced learning. ***Higher Education, 54***(1), 21-39.

The introduction of technology enhanced learning (TEL) methods changes the deployment of the most important resource in the education system: teachers' and learners' time. New technology promises greater personalization and greater productivity, but without careful modeling of the effects on the use of staff time, TEL methods can easily increase cost without commensurate benefit. The paper examines different approaches to comparing the teaching time costs of TEL with traditional methods, concluding that within-institution cost-benefit modeling yields the most accurate way of understanding how teachers can use the technology to achieve the level of productivity that makes personalisation affordable. The analysis is used to generate a set of requirements for a prospective, rather than retrospective cost-benefit model. It begins with planning decisions focused on realizing the benefits of TEL, and uses these to derive the likely critical costs, hence the reversal implied by a 'benefits-oriented cost model'. One of its principal advantages is that it enables innovators to plan and understand the relationship between the expected learning benefits and the likely teaching costs.

8 Angelou, G. N., & Economides, A. A. (2007). E-learning investment risk management. Information ***Resources Management Journal, 20***(4), 80-104.

E-learning markets have been expanding very rapidly. As a result, the involved senior managers are increasingly being confronted with the need to make significant investment decisions related to the elearning business activities. Real options applications to risk management and investment evaluation of Information and Communication Technologies (ICT) have mainly focused on a single and a priori known option. However, these options are not inherent in any ICT investment. Actually, they must be carefully planned and intentionally embedded in the ICT investment in order to mitigate its risks and increase its return. Moreover, when an ICT investment involves multiple risks, by adopting different series of cascading options we may achieve risk mitigation and enhance investment performance. In this article, we apply real options to the e-learning investments evaluation. Given the investment's

requirements, assumptions and risks, the goal is to maximize the investment's value by identifying a good way to structure it using carefully chosen real options. © 2007, IGI Global.

98 Bunkell, J., & Dyas-Correia, S. (2009). E-Books vs. print: Which is the better value? ***Serials Librarian, 56***(1-4), 215-219.

Jonathan Bunkell, Vice President of Online Book Sales for Elsevier, Ltd., presented an examination of e-books versus print books in order to assess which is the better value. The presenter considered the advantages of collecting online books as opposed to print, presented evidence that online books are a cost-effective solution that becomes more cost-effective over time, and demonstrated that e-books optimize usage of book titles, optimize their access and discoverability, and cross-link books with other online content for a dynamic research experience.

106 Cohen, A., & Nachmias, R. (2006). A quantitative cost effectiveness model for Web-supported academic instruction. ***Internet and Higher Education, 9***(2), 81-90.

This paper describes a quantitative cost effectiveness model for Web-supported academic instruction. The model was designed for Web-supported instruction (rather than distance learning only) characterizing most of the traditional higher education institutions. It is based on empirical data (Web logs) of students' and instructors' usage implementing Web-mining techniques. This will enable to quantify the costs and benefits of Web-supported instruction on both the single-course and the campus-wide levels. This paper describes the model's characteristics; the costs and benefits components in six dimensions; the computational mechanism that translates the cost and benefit components into quantitative values referring to university policymakers, instructors, and students; and its development process consists of the model design, creation of the computational mechanism and validation by instructors and students.

167 Cohen, A., & Nachmias, R. (2009). Implementing a cost effectiveness analyzer for web-supported academic instruction: A campus wide analysis. ***European Journal of Open, Distance and E-Learning*** (online article).

This paper describes the implementation of a quantitative cost effectiveness analyzer for Websupported academic instruction that was developed in Tel Aviv University during a long term study. The paper presents the cost effectiveness analysis of Tel Aviv University campus. Cost and benefit of 3,453 courses were analyzed, exemplifying campus-wide analysis. These courses represent large-scale Web-supported academic instruction processes throughout the campus. The findings were described, referring to students, instructors and university from both the economical and educational perspectives. The cost effectiveness values resulting from the calculations were summarized in four "coins" (efficiency coins=$; quality coins; affective coins; and knowledge management coins) for each of the three actors (students, instructors and university). In order to examine the distribution of those values throughout the campus assessment scales were created on the basis of descriptive statistics. The described analyzer can be implemented in other institutions very easily and almost automatically. This enables us to quantify the costs and benefits of Web-supported instruction on both the single course and the campus-wide levels.