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The Impact of the Modified Know-Want-Learn Strategy on Students' Performance and Metacognition in Primary School Physics Teaching

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Preface

Physics is generally regarded as difficult and uninteresting subject. Due to this fact, a number of average primary school students achieve low performance in physics. Students do not have satisfactory functional knowledge in this subject. Therefore, physics teachers should find the way to help students to better acquire physics contents and that should result in better students' performance.

It is shown that different teaching strategies can help students in learning physics contents but there is no strategy that can be regarded as the best. It is helpful to find various strategies appropriate to use in physics class to encourage students' learning and inquiry. In that way, the teacher can decide which strategy will fit best in certain conditions. Strategy should be selected depending on the teaching contents, structure of the class and teacher's personal affinity. Since there is a correlation between students' performance and metacognition, it is desirable to apply strategies that at the same time encourage the development of metacognition.

This PhD thesis is the result of research carried out with the aim to examine the effects of the modified Know-Want-Learn strategy on primary school students' achievement in physics and metacognition. It has been written to fulfill the requirements of the study programme Ph.D. in Teaching methods in life science, mathematics and computer science (Physics) at the Faculty of Sciences, University of Novi Sad.

The dissertation consists of the following five chapters: (1) Introduction, (2) Theoretical Framework, (3) Methodology of Research, (4) Research Results and Discussion and (5) Conclusions.

In this (first) chapter of the dissertation, the position of physics in primary education in the Republic of Serbia was analysed, the objectives and tasks of teaching physics were outlined, and the structure of dissertation is presented.

The second chapter provides a theoretical framework of the research. This chapter discusses students' performance in physics, students’ metacognition and the strategy Know-Want-Learn, as well as its modifications.

The third part of the dissertation is the Methodology of Research. This part presents information about: research problem, aim, hypotheses, questions, methods, sample, design and procedure, instruments of data collection and statistical analysis of data.

The fourth chapter presents the results of the analyses, their interpretation and discussion in conjunction with other literature. This chapter includes three parts: (1) the impact of the modified Know-Want-Learn strategy and gender on students’ performance, (2) the impact of the modified Know-Want-Learn strategy and gender on students’ metacognition, and (3) the relationship between students’ performance and metacognition.

In the Conclusions (Chapter 5), limitations of the conducted research, theoretical contribution, as well as the implications for practice and further research, is presented.

At the end of the dissertation, references are listed and the research instruments are shown in the Appendixes.

A part of this PhD thesis is published in paper:

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Contents

Prošireni apstrakt (Summary in Serbian Language)

Uticaj modifikovane strategije Znam-Želim da znam-Naučio sam na postignuća i metakogniciju učenika u osnovnoškolskoj nastavi fizike

Učenici doživljavaju fiziku kao težak nastavni predmet i imaju predrasude o fizici kao nauci i pre nego što se upoznaju sa njenim sadržajem u okviru nastave fizike. Delovi nastavnog sadržaja fizike su kompleksni i apstraktni, a za uspeh u fizici, neophodno je i poznavanje složenog matematičkog aparata. Učenici na svim nivoima obrazovanja, počev od osnovne škole, ostvaruju niska postignuća u fizici i nemaju zadovoljavajuće funkcionalno znanje iz fizike. Na to ukazuju rezultati različitih testiranja poznavanja prirodnih nauka, a posebno primene stečenih znanja u okviru PISA testa. Jedan od razloga loših rezultata koje učenici postižu u takvim prilikama je što se prilikom učenja fizike memorišu činjenice, definicije i zakoni, zbog čega učenička postignuća ostaju na niskom nivou kognitivnog domena – nivou reprodukcije.

Slaba postignuća učenika iz fizike ukazuju na potrebu da se u nastavi primenjuju odgovarajuće strategije koje mogu pomoći učenicima u savladavanju sadržaja fizike. S obzirom na to da postoji veza između postignuća i metakognicije učenika, poželjno je primenjivati strategije koje istovremeno podstiču razvoj metakognicije. Pojmu metakognicija su dodeljivana različita značenja, ali većina istraživača smatra da se metakognicija odnosi na razmišljanje pojedinca, nadgledanje i kontrolu razmišljanja. U okviru ovog pojma mogu se izdvojiti mnoge komponente: znanje o kognitivnim procesima (svesnost o vlastitom znanju, procesima mišljenja, kao i procesima učenja i usvajanja znanja), regulacija kognitivnih procesa (svesnost o potrebi korišćenja određenih strategija, kao što su planiranje, upravljanje informacijama, nadgledanje, evaluacija i otklanjanje grešaka prilikom misaonog procesa) i metakognitivni doživljaji (na primer, sigurnost u znanje).

Strategija Znam-Želim da znam-Naučio sam (Know-Want-Learn Strategy) je prvobitno predložena kao strategija čitanja. Navedena strategija je, kao pogodna za učenje na osnovu tekstualnog materijala, počela da se koristi u nastavi. Ona pomaže učenicima da organizuju svoje ideje, pitanja i odgovore na ta pitanja. Postupak se sastoji u popunjavanju tabele koja ima tri kolone: Znam (Z), Želim da znam (Ž) i Naučio sam (N). Tabela se popunjava pre i nakon čitanja teksta. U prvu kolonu učenik upisuje ono što već zna o datoj temi i na taj način se postiže aktivacija postojećeg znanja. Zatim u drugu kolonu učenik upisuje šta želi da zna o datoj temi, a nakon čitanja teksta u treću kolonu učenik zapisuje ono što je naučio.

Strategiju Znam-Želim da znam-Naučio sam je prvobitno razvila Ogl (Ogle) i opisala je u svom radu 1986. godine. Pokazano je da se primenom ove strategije podstiče aktivno učenje (Bryan, 1998; Draper, 2002; Jared & Jared, 1997; Ogle, 2009), kao i da se postiže aktivacija postojećeg znanja (Martorella, Beal & Bolick, 2005; Riswanto, Risnawati & Lismayanti, 2014).

Utvrđen je značaj prethodnog znanja učenika i sposobnosti aktiviranja tog znanja za proces učenja (Ausubel, 1968; Beck, Omanson, & McKeown, 1982; Gillani, 2003). Pored identifikacije prethodnog znanja, bitno je shvatanje odnosa između onoga što je poznato i onoga što se može saznati. Od primarnog značaja je teorija Osibela (1968) koja se oslanja na osnovne konstruktivističke principe, što se ogleda u zaključku da su učenici u stanju da, u interakciji sa okolinom, aktivno saznaju nove i napredne strategije za učenje (Hess, & Trexler, 2005; Siegler & Ellis, 1996). Razvoj značenja pojma započinje tako što učenici pristupaju sopstvenom sistemu prethodno uskladištenih informacija (Lipson, & Wixson, 1991), koji je nazvan prethodnim znanjem (Ausubel, 1968; Anderson, 1977; Gagne, 1985). Potom se ovaj proces dalje odvija na taj način što svaki učenik odabira specifičnu informaciju iz tog sistema, što podrazumeva selekciju koja se zasniva na spoznanju relevantnosti te informacije. Ta interakcija („razmena“) između učenika, njegovog prethodnog znanja i novih znanja je opisana od strane Rumenhalta (1977) u teoriji sheme i odnosi se na opštu teoriju znanja i pamćenja (Maria, 1990). Okruženje u kojem se učenje odvija može se shvatiti kao sklop promenljivih, vezanih za: učenika, tekst, kontekst i učitelja (Idol, 1988; Lipson, & Wixson, 1991). Na osnovu ovog saznanja čitanje može biti opisano kao aktivnost kojom učenici konstruišu značenje na osnovu teksta, logičnim vezivanjem onoga što je već poznato sa nagoveštajima unutar teksta (Anderson, Hiebert, Scott, & Wilkinson, 1985; Pearson, 1985). Strategija Znam-Želim da znam-Naučio sam omogućava učenicima da povežu prethodno znanje sa novim znanjem.

Literaturni podaci ukazuju na porast učeničkih postignuća nakon primene strategije Znam-Želim da znam-Naučio sam prilikom učenja različitih nastavnih sadržaja (Al-Khateeb & Idrees, 2010; Brozo & Simpson, 1991; Foote, Vermette & Battaglia 2001; Gammill, 2006;

Tran, 2015). Takođe, brojna istraživanja ukazuju na to da primena ove strategije podstiče razvoj metakognicije (Gammill, 2006; Mclain, 1993; Mok et al., 2006; Ogle, 2005; Szabo, 2006; Tok, 2013).

Posebno je analizirana značajnost/doprinos učeničkih pitanja i njihovog prethodnog znanja (koji su navedeni u tabelama) na dalju reorganizaciju njihove individualne kognitivne strukture (Taboaga & Guthrie, 2006). S obzirom na to da se ova strategija bazira na konstruktivizmu (Dammani, 2012), eksplicitno na Osibelovoj asimilacionoj teoriji učenja u kojoj je centralna ideja smisleno učenje, novi koncepti se ugrađuju u već postojeći sistem znanja (Ausubel, Novak & Hanesian, 1978).

Strategija Znam-Želim da znam-Naučio sam dalje je modifikovana prilagođavanjem tabele različitim učeničkim aktivnostima. U radovima su opisani primeri primene nekoliko modifikacija ove strategije, kao i analiza njihovog uticaja na različite varijable. Jedna od prvih je strategija Znam-Želim da znam-Naučio sam Plus, koju je predložila Ogl (1987), koja u odnosu na originalnu dodaje primenu koncept mapa i sumiranje sadržaja. Koncept mape su primenjene iz razloga što se one kao vizuelna nastavna tehnologija baziraju upravo na Osibelovoj asimilacionoj teoriji učenja i dodavanju novih koncepata u već postojeći sistem znanja (Stanisavljević & Stanisavljević, 2017). Drugi istraživači predlažu primenu različitih tabela: Znam-Želim da znam-Naučio sam-Kako mogu naučiti više (Cavner, 2013; Sumardiono, 2013; Weaver, 1994; Walker Tileston, 2004); Mislim-Želim da znam-Naučio sam (Akerson, 2001); Šta misliš-Kako možemo otkriti-Šta zaključujemo (Crowther & Cannon, 2004); Šta mislimo da znamo-Šta učimo-Koji dokazi to potkrepljuju-O čemu još uvek razmišljamo-Koji naučni principi pomažu da se objasni pojava (Hershberger, Zembal-Saul & Starr, 2006; Hershberger & Zembal-Saul, 2015); Znam činjenice-Nije od značaja-Želim da otkrijem-Primenjena strategija (Sumardiono, 2014).

Zbog specifičnosti saznavanja u nastavi fizike, strategija Znam-Želim da znam-Naučio sam se retko primenjuje za obradu nastavnog sadržaja ovog predmeta. Modifikacija strategije Znam-Želim da znam-Naučio sam, koja će biti predložena u ovom radu, se može koristiti u nastavi fizike s ciljem podsticanja istraživanja i praktičnog rada.

U okviru modifikovane strategije učenici popunjavaju tabelu od četiri kolone: Mislim i znam (M), Pitanja koja imam (P), Kako mogu da saznam (K) i Naučio sam (N). Razlika u odnosu na originalnu strategiju je u tome što u okviru prve kolone učenici pored onog što već znaju o datoj temi upisuju i svoje pretpostavke. U drugoj koloni učenici zapisuju svoja pitanja. Zatim, u koloni koja je dodata u odnosu na prvobitnu tabelu, učenici upisuju svoju ideju o tome na koji način mogu naći odgovor na postavljena pitanja (da li će to biti čitanje odgovarajuće literature, pretraživanje interneta, posmatranje određene pojave, izvođenje eksperimenta i drugo). Nakon što je nastavni sadržaj obrađen, učenici u poslednjoj koloni upisuju šta su naučili.

Cilj primene predložene strategije je da učenici ostvare bolja postignuća iz fizike. Procena učeničkih postignuća u kognitivnom području se može vršiti u skladu sa Blumovom taksonomijom obrazovnih ciljeva i ishoda u kognitivnom području (Bloom, 1981). Nakon što je predložena pedesetih godina dvadesetog veka, ova taksonomija je empirijski proveravana i razvijana. Prvobitnu verziju Blumove taksonomije revidirali su 1990. godine Anderson i Kratvol, koji su učestvovali i u formiranju prvobitne verzije.

Poželjno je primenjivati strategije koje utiču na učenička postignuća i istovremeno podstiču razvoj metakognicije. Prva istraživanja metakognicije se odvijaju od sedamdesetih godina dvadesetog veka i imaju korene u razvojnoj psihologiji i kognitivnoj psihologiji (Flavell, 1966; Kuhn & Dean, 2004). Opisivanje metakognicije je usmereno na metakognitivna znanja i metakognitivne doživljaje (Flavell, 1976). Pojmu metakognicija su dodeljivana različita značenja, ali većina istraživača smatra da se metakognicija odnosi na razmišljanje pojedinca, nadgledanje, osmatranje i kontrolu nad razmišljanjem (Kuhn & Dean, 2004; Brown, 1984; Lin, 2001). Izvršena su mnoga istraživanja o načinu merenja metakognitivnih sposobnosti (Schraw & Sperling, 1994; Sperling, Howard, Miller, & Murphy, 2002; Schraw, 2009), a posebnu pažnju mnogi istraživači su posvetili „osećanju da se zna“ (pojavi i njenom merenju) (Hart, 1965; Maril, Simons, Mitchell, Schwartz, & Schacter, 2003; Richards, & Nelson, 2004), načinima podsticanja metakognitivnih sposobnosti različitim strategijama i nastavnim metodama kao i uticaju metakognitivnih sposobnosti na postignuća i stavove učenika (Schraw, 1998; Schneider, 2008; Gok, 2010; Bayata, & Tarmizi, 2010).

Prvo poglavlje ove disertacije čini Uvodni deo. U ovom delu disertacije je opisan položaj fizike u osnovnom obrazovanju, navedeni su ciljevi i zadaci nastave fizike i predstavljena je struktura rada. U drugom poglavlju dat je teorijski okvir istraživanja. U ovom poglavlju razmatrana su pitanja postignuća učenika u fizici, metakognicije učenika i strategije Znam-Želim da znam-Naučio sam, kao i njene modifikacije. Treći deo disertacije je Metodologija istraživanja. U okviru ovog dela navedeni su problem i predmet istraživanja, cilj i zadaci istraživanja, uzorak istraživanja, metode istraživanja, organizacija i tok istraživanja, tehnike i instrumenti prikupljanja podataka i metode obrade podataka. U četvrtom poglavlju Rezultati istraživanja i diskusija opisani su: uticaj modifikovane strategije Znam-Želim da znam-Naučio sam i pola na postignuća učenika; uticaj modifikovane strategije Znam-Želim da znam-Naučio sam i pola na metakogniciju učenika, i povezanost između postignuća i metakognicije učenika. U Zaključku (petom poglavlju), diskutovano je o ograničenjima sprovedenog istraživanja i teorijskom doprinosu nauci o nastavi, kao i implikacijama za praktičan rad u školama. Na kraju rada su navedeni literaturni izvori koji su korišćeni i u okviru Priloga su prikazani korišćeni instrumenti (inicijalni i finalni test znanja iz fizike, kao i upitnik kojim je procenjena metakognicija učenika).

Predmet istraživanja. Predmet ovog istraživanja je ispitivanje uticaja modifikovane strategije Znam-Želim da znam-Naučio sam na postignuća i metakogniciju učenika u osnovnoškolskoj nastavi fizike.

Cilj i zadaci istraživanja. Cilj sprovedenog istraživanja bio je da se ispita da li će primena modifikovane strategije Znam-Želim da znam-Naučio sam pomoći učenicima u savladavanju sadržaja fizike i da li će istovremeno podsticati razvoj metakognicije učenika.

U skladu sa postavljenim ciljem, zadaci istraživanja su:

- Ispitati da li primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike utiče na postignuća učenika.
- Utvrditi da li postoje razlike u postignućima u odnosu na pol ispitanika.
- Ispitati da li primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike utiče na metakogniciju učenika.
- Utvrditi da li postoje razlike u metakogniciji u odnosu na pol ispitanika.
- Ispitati povezanost između postignuća i metakognicije učenika.

Očekivano je da će se istraživanjem pokazati sledeće:

- Primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike pozitivno utiče na postignuća učenika.
- Postoji razlika u postignućima među polovima ispitanika.
- Primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike pozitivno utiče na metakogniciju učenika.
- Postoji razlika u metakogniciji među polovima ispitanika.
- Postignuća učenika iz fizike su u pozitivnoj sprezi sa metakognicijom učenika.

Uzorak istraživanja. Uzorak istraživanja je biran prigodno. Ukupan uzorak činio je 141 učenik (5 odeljenja) šestog razreda osnovne škole (uzrasta 11-12 godina).

Metode istraživanja. U sprovedenom istraživanju su primenjene sledeće metode: analitička metoda, metoda pedagoškog eksperimenta (pedagoški eksperiment sa paralelnim grupama – eksperimentalnom i kontrolnom) i statistička metoda.

Instrumenti istraživanja. Postignuća učenika su procenjena primenom inicijalnog i finalnog testa koji su kreirani za potrebe istraživanja, dok je za procenu metakognicije učenika korišćen upitnik o nivou metakognicije – preveden i prilagođen upitnik Junior Metacognitive Awareness Inventory (Jr MAI), koji su razvili Sperling, Howard, Miller i Murphy (2002). Primenjeni instrumenti istraživanja su procenjeni kao validni i pouzdani.

Tok istraživanja. Istraživanje je realizovano u periodu od 14 nastavnih nedelja, kada su se realizovale nastavne teme: Masa i gustina i Pritisak, tokom školske 2015-2016. godine.

Na osnovu prosečnog uspeha učenika, njihovih postignuća na inicijalnom testu znanja i upitniku o nivou metakognicije, formirane su eksperimentalna i kontrolna grupa. Obe grupe su činila po dva odeljenja. Primenom t-testa nezavisnih uzoraka je pokazano da ne postoji statistički značajna razlika u opštem uspehu učenika kontrolne grupe ($M = 4.5370$, $SD = .60541$) i eksperimentalne grupe ($M = 4.5536$, $SD = .65836$); $t(108) = .137$, $p = .891$. Pored toga, na inicijalnom testu je pokazano da ne postoji statistički značajna razlika u postignućima učenika kontrolne grupe ($M = 10.67$, $SD = 4.57$) i eksperimentalne grupe ($M = 9.95$, $SD = 4.52$); $t(108) = -.831$, $p = .408$. Isto je pokazano i za metakogniciju učenika kontrolne grupe ($M = 72.04$, $SD = 8.068$) i eksperimentalne grupe ($M = 71.57$, $SD = 8.653$); t

(108) = .292, p = .771. Učenici eksperimentalne grupe su obučavani primenom modifikovane strategije Znam-Želim da znam-Naučio sam, dok su učenici kontrolne grupe obučavani primenom tradicionalne nastave. Nakon realizovanog eksperimentalnog istraživanja, učenici obe grupe su uradili finalni test znanja i popunili upitnik o nivou metakognicije.

Statistička obrada podataka. Za statističku obradu dobijenih podataka primenjeni su statistički paket IBM SPSS Statistics 20 i Microsoft Office Excel. Učenička postignuća i metakognicija su opisani deskriptivnim statističkim parametrima (aritmetička sredina, medijana, mod, standardna devijacija, koeficijent varijacije, maksimalni skor, minimalni skor, opseg, standardizovani skjunis i kurtozis). Razlike između postignuća i metakognicije učenika na inicijalnom i finalnom testu, u okviru eksperimentalne, kao i u okviru kontrolne grupe su ispitane primenom t-testa uparenih uzoraka. Razlike u postignućima i razlike u metakogniciji između učenika eksperimentalne i kontrolne grupe su ispitane primenom t-testa nezavisnih uzoraka, kao i razlike u postignuću i metakogniciji učenika između polova u okviru obe grupe. Pre primene t-testa uparenih uzoraka, odnosno t-testa nezavisnih uzoraka, je utvrđeno da podaci zadovoljavaju kriterijum normalne raspodele (što je ispitano Šapiro-Vilk testom i analizom dobijenih vrednosti za standardizovani skjunis i kurtozis). Učenička postignuća i metakognicija su prikazani i grafički. Povezanost između učeničih postignuća i metakognicije je ispitana pomoću korelacione i regresione analize.

Rezultati istraživanja. Rezultatima istraživanja je odgovoreno na postavljene zadatke istraživanja i potvrđene su ranije navedene pretpostavke.

Primenom t-testa uparenih uzoraka je pokazano da u okviru kontrolne grupe nije bilo statistički značajne razlike u postignuću učenika pre ($M = 10.67$, $SD = 4.57$) i posle ($M = 11.17$, $SD = 4.49$) eksperimenta; $t(53) = -1.88$, $p = .065$, dok je u eksperimentalnoj grupi zabeležen porast postignuća iz fizike nakon primene modifikovane strategije Znam-Želim da znam-Naučio sam ($M = 14.07$, $SD = 4.20$) u odnosu na postignuća ostvarena na inicijalnom testu ($M = 9.95$, $SD = 4.52$); $t(55) = -5.20$, $p < .0001$. Dodatno, primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike je rezultirala boljim postignućima učenika u odnosu na tradicionalni nastavni pristup. Rezultati t-testa nezavisnih uzoraka su pokazali da postoji statistički značajna razlika između postignuća učenika eksperimentalne grupe ($M = 14.07$, $SD = 4.20$) i kontrolne grupe ($M = 11.17$, $SD = 4.49$) na finalnom testu; $t(108) = -3.505$, $p = .001$.

Pokazano je da ne postoji statistički značajna razlika u postignućima među polovima ispitanika. Ovo je pokazano primenom t-testa uparenih uzoraka na ostvarene rezultate učenika i učenica, na inicijalnom i na finalnom testu, kako u eksperimentalnoj, tako i u kontrolnoj grupi. U kontrolnoj grupi, na inicijalnom testu su učenici ostvarili: M = 10.16, SD = 4.007, a učenice: M = 11.10, SD = 5.038; vrednost t-testa je t (52) = -.753, p = .455. Isti učenici su na finalnom testu ostvarili: M = 10.80, SD = 3.937, a učenice: M = 11.48, SD = 4.961; t (52) = -.554, p = .576. U eksperimentalnoj grupi su rezultati inicijalnog testa za učenike: M = 9.81, SD = 4.280, a za učenice: M = 10.07, SD = 4.785; t(54)= -.212, p=.833; dok su rezultati finalnog testa za učenike: M = 15.19, SD = 4.079, a za učenice: M = 13.10, SD = 4.130; t (54) = 1.901, p =.063. Takođe, pokazano je da primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike ima pozitivan uticaj na postignuća učenika oba pola.

Kako bi se ispitala razlika u metakogniciji učenika na inicijalnom i finalnom testu, primenjen je t-test uparenih uzoraka. Kod učenika kontrolne grupe nije bilo statistički značajne razlike u metakogniciji pre pedagoškog eksperimenta (M = 72.04, SD = 8.068) i posle (M = 71.22, SD = 8.144); t (53) = 1.993, p = .051. Kod učenika eksperimentalne grupe je pokazano da postoji statistički značajna razlika u metakogniciji na inicijalnom (M = 71.57, SD = 8.653) i finalnom (M = 76.18, SD = 6.478) testu; t (55) = -4.658, p < .0001. Primenom t-testa nezavisnih uzoraka pokazano je da postoji statistički značajna razlika između postignuća učenika eksperimentalne grupe (M = 76.18, SD = 6.478) i kontrolne grupe (M = 71.22, SD = 8.144) na finalnom testu; t (108) = -3.505, p = .001. Na osnovu navedenog može se sugerisati da primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike pozitivno utiče i na metakogniciju učenika.

Postoji statistički značajna razlika u metakogniciji učenika u odnosu na pol, što je utvrđeno primenom t-testa nezavisnih uzoraka. Rezultati testa su pokazali da su učenice pokazale viši nivo metakognicije od učenika. U kontrolnoj grupi, na upitniku o nivou metakognicije u okviru inicijalnog testiranja su učenici ostvarili: M = 69.24, SD = 6.260, a učenice: M = 74.45, SD = 8.753; t (52) = -2.477, p = .017. Isti učenici su tokom finalnog testiranja ostvarili: M = 68.84, SD = 6.149, a učenice: M = 73.28, SD = 9.149; t (52) = -2.056, p = .045. U eksperimentalnoj grupi na inicijalnom testianju je vrednost metakognicije za učenike: M = 68.65, SD = 7.864, a za učenice: M = 74.10, SD = 8.628; t (54) = -2.454, p = .017; dok je na finalnom testiranju za učenike: M = 74.23, SD = 6.936, a za učenice: M = 77.87, SD = 5.637;

t (54) = -2.164, p = .035. Strategija primenjena u eksperimentalnoj grupi imala je pozitivan uticaj na metakogniciju učenika oba pola.

Pirsonova korelacija je pokazala da postoji statistički značajna pozitivna veza između učeničkih postignuća i metakognicije na inicijalnom i finalnom testu u okviru ukupnog uzorka. Dobijene vrednosti za inicijalni i finalni test su: r (110) = .311, p = .001 i r (110) = .252, p = .008, respektivno. Isto je pokazano i u okviru kontrolne grupe, za inicijalni test: r (54) = .336, p = .001 i za finalni test: r (54) = .454, p = .001. U okviru eksperimentalne grupe pokazano je da je ova veza statistički značajna samo na inicijalnom testu: r (56) = . 287, p = .008, dok na finalnom testu nije: r (56) = -.205, p = .130. Jačina za pokazane veze je slaba do umerena. Dobijeni rezultati su interesantni jer se, na osnovu toga što je pokazano da na finalnom testu kod učenika u eksperimentalnoj grupi ne postoji statistički značajna veza između postignuća i metakognicije, može sugerisati da iako je pokazano da primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike pozitivno utiče na učenička postignuća i metakogniciju, njen uticaj nije jednak na ove dve promenljive za sve učenike.

Dobijeni rezultati su ukazali na to da primena modifikovane strategije Znam-Želim da znam-Naučio sam u osnovnoškolskoj nastavi fizike ima pozitivan uticaj na postignuća i metakogniciju učenika. Pokazano je da navedena strategija ima pozitivan uticaj na učenike oba pola. Pošto predložena i opisana strategija uzima u obzir specifičnost nastave fizike, može se koristiti u nastavi ovog školskog predmeta s ciljem povećanja učeničkih postignuća i podsticanja metakognicije. Na osnovu rezultata ovog istraživanja o pozitivnim efektima ove strategije, može se sugerisati nastavnicima fizike da je primenjuju. Na taj način se može unapređivati nastava fizike.

Ograničenja sprovedenog istraživanja se ogledaju u obimu uzorka, dužini trajanja eksperimenta i obimu programskih sadržaja koji je obuhvaćen ovim eksperimentom. Uzorak je bio biran prigodno što je uticalo na veličinu uzorka. Iako su kontrolna i eksperimentalna grupa ujednačene u pogledu učeničkih postignuća i metakognicije, učenici nisu nasumično raspoređeni u jednu, ili drugu grupu, jer su pripadali već formiranim odeljenjima.

Na osnovu rezultata i ograničenja sprovedenog istraživanja, može se ukazati na smer u kome bi trebalo da se vrše buduća istraživanja u vezi sa primenom opisane strategije u nastavi fizike. Ukoliko se buduća istraživanja realizuju sa ciljem sticanja novog uvida primene predložene strategije, bilo bi značajno ispitati drugi uzorak ispitanika u pogledu uzrasta i proširiti uzorak gradiva. Može se dodatno ispitati uticaj koji primena modifikovane strategije Znam-Želim da znam-Naučio sam u nastavi fizike ima na stavove učenika o fizici, motivaciju, kognitivno opterećenje, ili druge varijable. Takođe, veliki značaj opisane strategije se ogleda u tome što pruža mogućnost identifikacije učeničkih miskoncepcija. Primena ove strategije može imati više pozitivnih efekata nego što je u ovom istraživanju nagovešteno.

1. Introduction

Students at all levels of education, starting from primary school, achieve low performance in physics and do not have satisfactory functional knowledge of this subject. This is indicated by the results of various tests of knowledge of natural sciences, such as a test for the application of acquired knowledge within the TIMSS for the eighth grade and PISA. One of the reasons for the poor results that students achieve on such occasions is that when learning physics, facts, definitions and laws are memorized. Because of that, students' performance remains at the lowest level - the level of reproduction.

According to Taslidere and Eryilmaz (2012), “in recent decades researchers have studied the problem of students’ inadequate reading and study habits, their unwillingness to study physics and their difficulties in understanding it.” Students are used to rely upon teacher for constant support, instead of being independent learners, aware of their own learning. Those problems are reflected in students’ physics achievements and are related to students’ metacognition.

Therefore, physics teachers should find a way to help students to better acquire physics contents which should result in better marks in physics. Since different students react differently to particular teaching and learning strategies, it is desirable to determine various strategies that are possibly useful in order to enhance students’ acquiring of physics contents. Besides, various studies are implying that physics is generally regarded as conceptually difficult, abstract and uninteresting and that many students unwillingly study physics (Ancell, Guttersrud, Henriksen & Isnes, 2004; Checkley, 2010; Williams, Stanisstreet, Spall, Boyes & Dickson, 2003; as cited in Erinosho, 2013). In order for students to reach their full potential in science class, teachers must be well prepared for teaching (Hayes, 2002, Munck, 2007). Teachers have to find a way to enhance students’ achievement. It is shown that using an adequate learning strategy is in correlation with students’ achievement in different subjects (Yumuşak, Sungur & Çakıroğlu, 2007), including physics (Sağlam, 2010). Learning strategies can be defined as “behaviors and thoughts that a learner uses for processing information during learning” (Weinstein & Mayer, 1986; as cited in Selçuk, 2010). Each student is interested in different contents and activities. Therefore, learning strategies should be modified accordingly, in order to help them in acquiring knowledge (Ekwensi, Moranski & Townsend-Sweet, 2006).

1.1. Primary School Physics in the Republic of Serbia

In the Republic of Serbia, students enroll in primary school between age 6 and 7 and primary education is divided into two cycles: first cycle (1st-4th grade) and second cycle (5th-8th grade) (with two classes of Physics per week, 72 per year). In the first cycle, students learn elements of physics within two school subjects: The world around us (in first and second grade) and Nature and society (in third and fourth grade) (Bošnjak, Obadović & Bogdanović, 2016). As an elective subject, the Hands-on – Discovery of the World (La Main à la pâte) is offered from the first to the fourth grade (one time a week, 36 per year) (Sl. Glasnik RS – Prosvetni glasnik, 1/2005, 15/2006, 2/2008, 2/2010, 7/2010, 3/2011).

In the second cycle of primary school, there are three separate subjects in which different sciences are being taught by the different subject teachers: Biology (from fifth to eighth grade, with two classes per week), Physics (from sixth to eighth grade, with two classes per week) and Chemistry (from seventh to eighth grade, with two classes per week) (Sl. Glasnik RS – Prosvetni glasnik, 6/2007, 2/2010, 7/2010, 3/2011). However, students do not see any connection between contents of these subjects and science contents taught in lower grades (Zouhor, Bogdanović, Skuban, & Pavkov-Hrvojević, 2017).

Although, physics is introduced as a separate school subject for Serbian students in their sixth grade of primary school (that is regulated in curriculum determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia), sixth-grade students (aged 11–12 years) already have prejudices that physics is a difficult subject and most students do not try to be good at it. Due to this fact, a number of average primary school students in the Republic of Serbia have bad marks in physics (marks are based on tests results and oral examinations).

According to curriculum determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia, the content of Physics includes the following topics in the sixth grade: (1) Introduction, (2) Motion, (3) Force, (4) Measurement, (5) Mass and density and (6) Pressure (Sl. Glasnik RS – Prosvetni glasnik, 5/2008). Topics taught in seventh grade are: (1) Force and motion, (2) Motion of the body under the force of gravity. Frictional forces, (3) Balance, (4) Mechanical work and energy, (5) Power and (6) Thermal phenomena (Sl. Glasnik RS – Prosvetni glasnik, 6/2009); and in eighth grade: (1) Oscillatory and wave motion, (2) Light phenomena, (3) Electrical field, (4) Electric current, (5) Magnetic field, (6) Elements of atomic and nuclear physics, and (7) Physics and the modern world (Sl. Glasnik RS – Prosvetni glasnik, 2/2010). In addition to the offered content, the topics for which the students show a special interest, or the topics selected by students, can be realized as part of additional classes.

1.2. Physics Goals and Objectives

The significance of physics lies in its impact on the development of the economy and technology (Zhaoyao, 2002). Since, in modern society, science finds its place in everyday life and work, education should help students to be scientifically literate and prepare them to use science knowledge (Tytler, 2014). Physics should provide students with a conceptual framework and factual knowledge, as well as analytical and scientific skills. The basic goal of teaching physics is to ensure that all students acquire basic language and scientific literacy. After completing primary education physics, students should be able to solve problems and tasks in new and unknown situations, to express and explain their thinking and discuss with others. Teaching physics should develop learning motivation and interest in the subject matter, as well as to learn about natural phenomena and basic natural laws. Further, students should be able to detect and recognize physical phenomena in everyday life and to be prepared for active studying of physical phenomena through research. Students should acquire knowledge about the basis of the scientific method. In that way they will develop and improve skills for scientific inquiry; they will understand the inquiry process and they will be able to perform it. Physics should guide students to focus on the application of physical laws in everyday life and work (Sl. Glasnik RS – Prosvetni glasnik, 5/2008, 3/2011).

According to curriculum determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia, the goals and objectives of teaching physics are realized through the basic forms of teaching: (1) lectures and appropriate demonstrations, (2) solving qualitative and quantitative tasks, (3) laboratory exercises, (4) use of other activities that contribute to better understanding of the topic (homework, reading popular literature, history of physics) and (5) systematic monitoring of the work of each individual student. When performing the first three forms of teaching, a teacher should emphasize their unification for a unique goal: the discovery and formulation of laws and their application. Otherwise, a student may get the wrong impression that theory, computational tasks, and experiments exist independently as three “different physics”. In order to achieve the goals of teaching physics, it is necessary for students to participate actively in all forms of teaching process (Sl. Glasnik RS – Prosvetni glasnik, 5/2008, 3/2011). Although possibly useful teaching strategies are not listed in curriculum, these strategies can help in achieving physics goals and objectives.

According to the programme prescribed for Physics, students should have basic knowledge of all areas of physics, upon completing compulsory education. In the field of classical physics, these are: mechanics, thermodynamics, sound, optics, electricity and magnetism. Besides, students should acquire, at the lowest level, the contents of contemporary physics: atomic, nuclear and particle physics.

2. Theoretical Framework

2.1. Students' Academic Performance in Physics

2.1.1. Promoting Students Performance in Physics

Educational system should enable students to acquire knowledge and skills. When one wants to define and plan educational change with the aim of improvement, students' academic performance is of great importance as an indicator. That is in both, broad and narrow terms, for example for planning curriculum changes and in choosing teaching strategies. It is shown that academic performance is a complex variable. Numerous variables can contribute to students' performance simultaneously, but there is researchers' tendency to analyze predictors for it separately (Ozel Caglak & Erdogan, 2013). Academic performance can be defined as the "scholastic standing of a student at a given moment". That scholastic standing can be considered on the basis of students' marks in a particular subject (Mallory, 2004). Performance measures outcomes of learning: changes in knowledge, skills and attitudes. Academic performance is dependent on students' performance in examinations and it is often expressed as average mark of all subjects (Al-Shorayye, 1995).

Lacambra (2016) stated that, in order to assess students' knowledge and skills as a result of learning process, one can use testing. Students' test scores provide very important information in both, formative and summative assessment. Teacher uses this information to assign final marks to students attending the course. Besides, one can distinguish students' strengths and weaknesses regarding particular course, as well as assess students' performance in class. Based on test results, teacher can improve his/her teaching methods and techniques in everyday school practice. In other words, test results can help teacher to evaluate whether a particular teaching method is efficient, and to make decision about its application. On the basis of test results, one can assess teachers' needs when carrying out certain curriculum. Moreover, information about test results can be criteria for evaluation of the certain curriculum.

Students' academic performance in physics refers to their results on examination in this subject. The teacher can evaluate students' performance based on written tasks, oral examinations, homework, laboratory work and similar. Based on teachers' assessment of students' work, the students get marks from 1 to 5, where 1 is insufficient and 5 is excellent .

There are many reasons for students' poor achievement in physics. For example, physics has a reputation of being a difficult and uninteresting subject (Clement, 1993; O'Keefe, 1997). That is often because in physics students must understand and/or use: experiments, formulas, numbers and calculations, graphs, and conceptual explanations (Angell, Guttersrud, Henriksen & Isnes, 2004; Seth, Fatin & Marlina, 2007). According to Lacambra (2016) students' performance in physics significantly depend on the students' preparation in Mathematics and English courses. Meaning that good performance in physics can achieve students who know both, mathematics and language. According to Blickenstaff (2010) physics is considered as tough and abstract discipline. Group of authors showed that that, in Finland, students' performance in Physics is lower than their performance in Chemistry and Biology (Lavonen, Meisano, Byman, Uiito & Juiit, 2005). Lack of laboratory equipment and unsatisfactory teaching can lead to low motivation for learning physics (Shedrack & Ikem, 2012), which reflects on students' performance in this subject.

Buabeng and colleagues stated that the traditional way of teaching (with the teacher who makes all decisions in the classroom) has unavoidable limitations in the education of 21st century, particularly in teaching physics (Buabeng, Ossei-Anto & Ampiah, 2014). In order to enable students to achieve their full potential in physics, teacher must use appropriate teaching practice that will be effective in a given situation (Borich, 2007; Fishburne & Hickson, 2001).

Although inquiry-based teaching can enhance students' performance, the research carried out in high schools in Ghana indicated that teacher-centered approach is used rather than student-centered approach. Based on that research, authors recommend that physics teachers need to be trained in pedagogy of teaching, as well as presenting information to students (Buabeng, Ossei-Anto & Ampiah, 2014). They identified many variables that influence learning outcomes and students' performance. The relationships between these variables is shown in Figure 2.1.

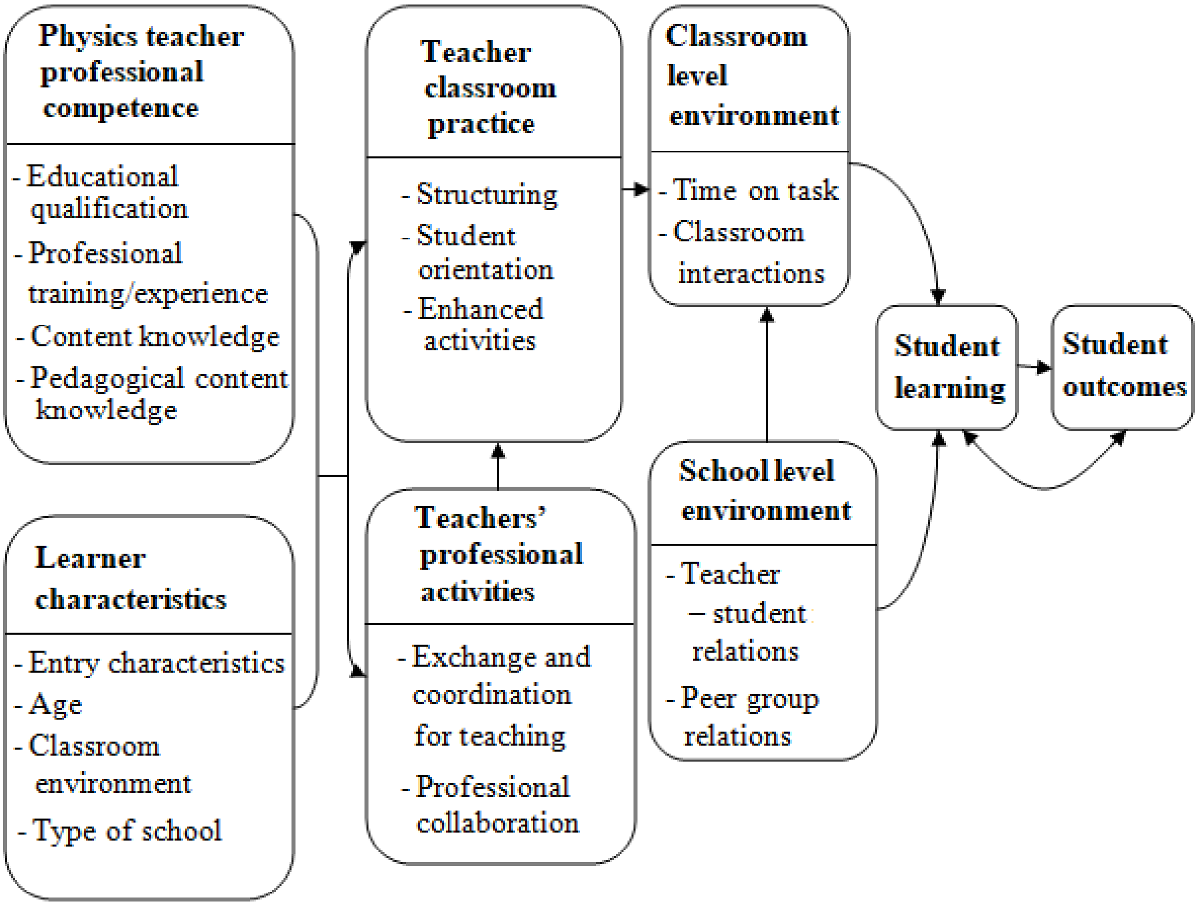

Figure 2.1: *Variables determining students' performance (Source: Buabeng, Ossei-Anto & Ampiah, 2014)*

Since students' attitudes can be predictors of students' performance (Hendrickson, 1997), change in attitudes can enhance students' success. Students' attitudes towards learning physics are dependent on many factors. A student can acquire attitude through learning, but it can be changed with the use of different techniques of persuasion (Ibeh, Onah, Umahi, Ugwuonah, Nnachi & Ekpe, 2013).

2.1.2. Bloom's Taxonomy of Educational Objectives

Three domains of educational activities are identified by a committee of colleges, led by Benjamin Bloom (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956):

- cognitive,
- affective and
- psychomotor.

The cognitive domain involves knowledge and the development of intellectual skills. The affective domain includes the emotional areas, attitudes, motivations, feelings, values, appreciation and enthusiasms (Krathwohl, Bloom, & Masia, 1973). The psychomotor domain refers to manual or physical skills such as physical movement, coordination and other. Bloom (1981) stated that education should have impact on students' thoughts, feelings and actions.

In each of the three domains, educational objectives are defined and hierarchically arranged (Figure 2.2). Bloom directly participated in the creation of taxonomy in the cognitive domain (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956), partly in an affective domain (Krathwohl, Bloom, & Masia, 1973), and various taxonomies of the psychomotor domain were developed by his followers (Dave, 1970; Harrow, 1972; Simpson, 1972).

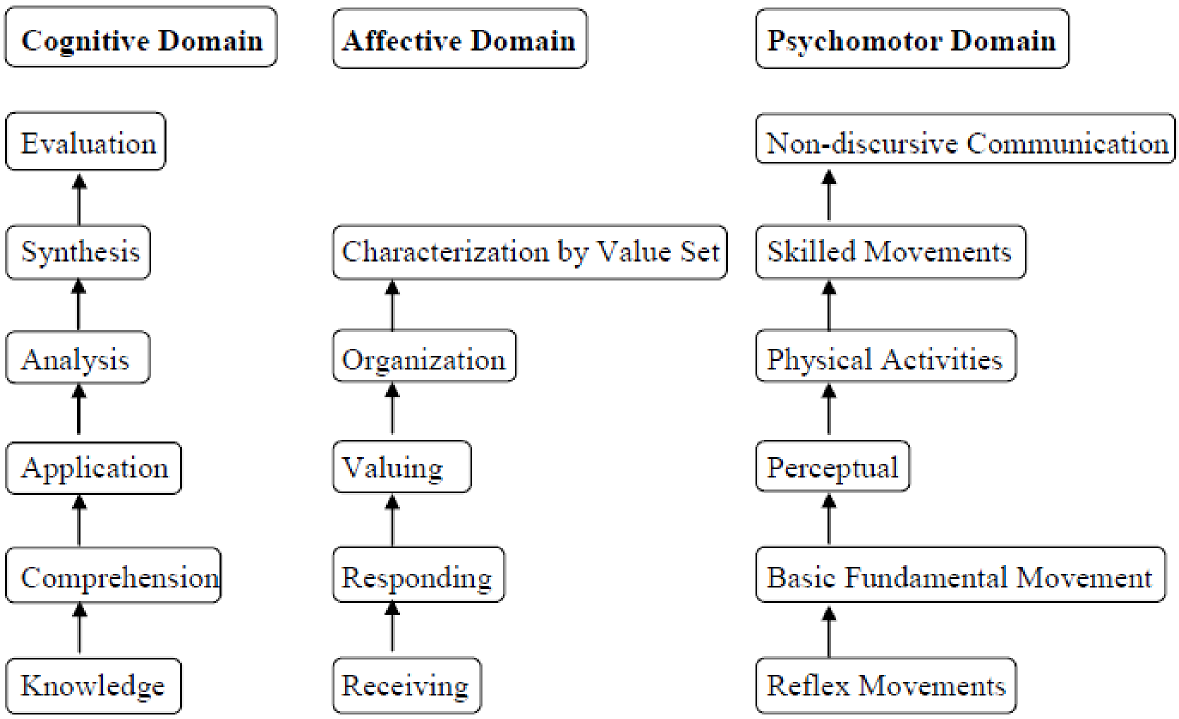

Figure 2.2: *Bloom's taxonomy of educational objectives in cognitive, affective and psychomotor domain*

The taxonomy of the psychomotor domain, shown in Figure 2.2, is developed by Harrow (1972**).**

Education should increase students' physical, cognitive, metacognitive, emotional and social skills. Level of developed skills indicates on efficiency of educational process. Accordingly, the Bloom’s taxonomy can be useful for “designing educational, training, and learning processes” (Clark, 2015). One of the results of teaching-learning process should be long lasting applicable knowledge. Aspect of physics learning efficiency referred to physics knowledge can be tested by knowledge tests which give us as feedback information on quality and quantity of students’ knowledge.

There are various taxonomies that describe the different cognitive levels, including taxonomies given by: Bloom, Quellmalz, Gagne, Marzano, Merrill (Moseley et al., 2005). Bloom (1956) identified six levels within the cognitive domain: knowledge, comprehension, application, analysis, synthesis and evaluation. The lowest level is the simplest – recall or recognition of facts. It is followed by more complex and abstract mental levels up to the highest – evaluation (Bloom, Engelhart, Furst, Hill & Krathwohl, 1956).

In addition to acquiring knowledge and developing skills for independent learning, the school should enable the development of all domains of students’ personality (Vučeljić & Čabrilo, 2008). Organization of teaching in the Republic of Serbia, as well as in many countries, supports learning contents of different subjects, but it is insufficiently focused on the developing skills for learning and on encouraging thinking. Education should develop students' physical, cognitive, metacognitive, emotional and social skills. Application of Bloom’s taxonomy in cognitive domain is useful for encouraging higher levels of thinking, for example: analysis and evaluation of concepts, as well as processes and principles. These levels should be promoted rather than lower levels such as knowledge (learning with the goal of remembering facts). Different taxonomies indicate how the evaluation of educational objectives can be done. For example, Bloom's taxonomy of educational objectives in cognitive domain allows measuring the achievement of students in the cognitive area (Forehand, 2005). When assessing physics knowledge, it is hard to recognize the nuances between some levels of cognitive domain suggested by Bloom. In physics one sometimes cannot apply knowledge without having knowledge in the higher level domains: analysis, synthesis and evaluation.

Each level of Bloom's taxonomy is defined and classified through the subclasses, thus encompassing special cognitive categories (Bloom, 1981). Bloom and associates (Bloom, 1981) explained each level of original taxonomy:

At the level of ***knowledge***, one can recognize or remember facts, terms, basic concepts, or answers. At this level, one does not need to understand the meaning of those facts. Level of knowledge includes: (1) knowledge of specifics: knowledge of terminology, and knowledge of specific facts; (2) knowledge of ways and means of dealing with specifics: knowledge of conventions, knowledge of trends and sequences, knowledge of classifications and categories, and knowledge of methodology; and (3) knowledge of the universals and abstracts in the field: knowledge of principals and generalizations, and knowledge of theories and structures.

The level of ***comprehension*** involves intellectual abilities and skills that enable understanding of contents and ideas. At the level of understanding, students should master the meaning of the content. He/she should be ready to discuss the results of the measurement, explain the phenomenon, cite examples and similar. Comprehension includes: (1) translation; (2) interpretation; and (3) extrapolation.

Application implies that a learner has mastered the previous cognitive domains, knowledge and understanding, that is, this level implies the knowledge and use of a generalization or an appropriate principle for a given problem. At the level of application, the student should be able to use acquired knowledge in new situations. He/she should be able to demonstrate the experiment, differentiate variables, state the problem, solve calculational tasks, illustrate the principles, and similar. The level of application is not hierarchically further classified.

Analysis requires a slightly higher level of cognitive abilities than comprehension and application. It emphasizes the breaking content on its constituent parts, as well as the discovery of the relationship between these parts and the ways in which they are related. The analysis may also be directed to techniques and means by which some content is communicated. At the level of the analysis, the student should understand the content, as well as the structure of the problem. He/she should be able to compare the results of measurements, analyze their numerous values, examine the connections, make conclusions, and similar. The level of analysis includes: (1) analysis of elements; (2) analysis of relationships; and (3) analysis of organizational principles.

Synthesis is the category of a cognitive domain in which the creativity of an individual is most evident. It is the process of assembling components and parts to a whole, that is, the process of combining elements in order to obtain a certain order or structure, which did not exist before that process. At the level of synthesis, the student should formulate and build new structures from existing knowledge and skills. He/she should be able to create and plan an experiment, assemble the apparatus, link physical quantities and phenomena. Synthesis includes: (1) production of a unique communication, (2) production of a plan or a proposed set of operations; and (3) derivation of a set of abstract relations.

Evaluation occurs last, in the complex processes in which there is a combination of all previous levels of cognitive domain – knowledge, comprehension, application, analysis and synthesis. Besides, evaluation includes criteria and standards. It is estimation of values for a purpose of various ideas, works, solutions, methods, and similar. It can be quantitative or qualitative, and the criteria may be different. At the evaluation level, student should be able to present the results of an experiment, evaluate and critically interpret them, make conclusions, and similar. The level of evaluation includes: (1) judgements in terms of internal evidence; and (2) judgements in terms of external evidence.

Bloom's taxonomy has been empirically tested and further developed. The original version of taxonomy was revised in 1990 by Anderson and Kratvwohl (Anderson & Krathwohl, 2001), who also participated in the developing of the original version. Due to the fact that the student has become an active participant in the learning process, because he/she actively selects information and constructs his/her own knowledge system based on them, the one-dimensional model from the original Bloom’s taxonomy was replaced by a two-dimensional model. This is an appropriate model for emphasizing learning with understanding, which is based on two dimensions of learning - what the student knows and how the student acquires knowledge and thinks. Accordingly, in the revised taxonomy, besides the dimension of knowledge, the dimension of cognitive process is introduced (Table 2.1).

Table 2.1: *Various combinations of the cognitive process dimensions and knowledge dimensions in revised Bloom's taxonomy (Source: Krathwohl, 2002)*

The Knowledge Dimension	**The Cognitive Process Dimension**					
	Remembering	Understanding	Applying	Analyzing	Evaluating	Creating
Factual						
Conceptual						
Procedural						
Metacognitive						

In revised Bloom's Taxonomy, four Types of Knowledge are described: (1) Factual Knowledge: Knowledge of Terminology, and Knowledge of Specific Details and Elements; (2) Conceptual Knowledge: Knowledge of Classifications and Categories, Knowledge of Principles and Generalizations, and Knowledge of Theories, Models, and Structures, (3) Procedural Knowledge: Knowledge of Subject-Specific Skills and Algorithms, Knowledge of Subject-Specific Techniques and Methods, and Knowledge of Criteria for When to Use Procedures; (4) Metacognitive Knowledge: Strategic Knowledge, Knowledge about Cognitive Tasks (Context and Conditions), and Self-Knowledge.

Students use cognitive processes while learning. The hierarchy of cognitive processes in the revised taxonomy is similar to hierarchy of cognitive levels of original Bloom's taxonomy. The cognitive processes listed in the revised taxonomy are: ***remembering, understanding, applying, analyzing, evaluating,*** and ***creating***. Another change in the structure of taxonomy is that the level of *synthesis* is replaced by the level of *creating*, which has become the highest level of knowledge, that is, in the revised taxonomy the highest level of cognitive processes.

The revised taxonomy, with explanations and examples for each dimension, is illustrated in Figure 2.3.

Figure 2.3: *A Model of Learning Objectives – based on A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives* (by Rex Heer, Center for Excellence in Learning and Teaching, Iowa State University is licensed under a Creative Commons Attribution-NonCommercial-ShareAlike 3.0 Unported License. Retrieved from: https://meestervormgever.wordpress.com/2015/02/05/revised-blooms-taxonomy-center-for-excellence-in-learning-and-teaching/

Besides, changes in taxonomy also refer to the change of terminology. Nouns were originally used for the names of the categories, and in the revised taxonomy categories have been renamed by using verbs. Comparison of the levels in the cognitive domain of the original Bloom's taxonomy and the cognitive process dimensions of revised taxonomy is shown in Figure 2.4, as well as comparison of the terms used in these taxonomies.

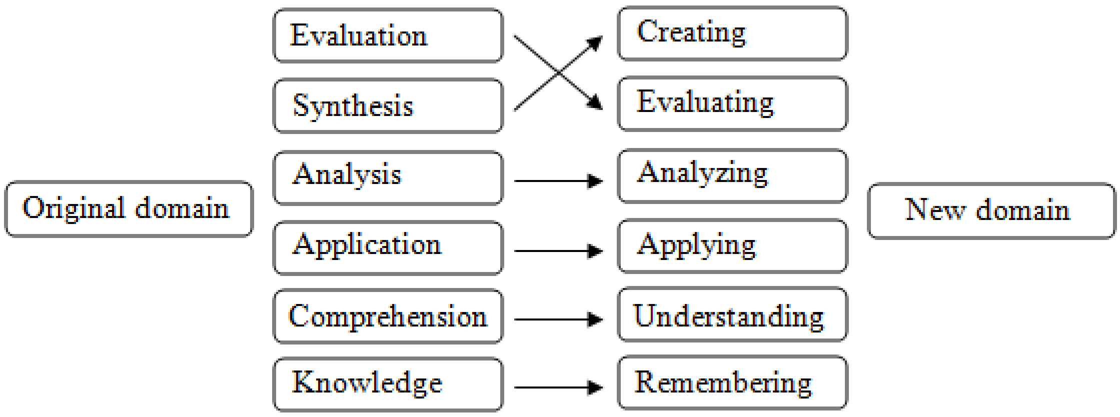

Figure 2.4: *Comparison of the levels in the cognitive domain of the original Bloom's taxonomy and the cognitive process dimensions of revised taxonomy*

Anderson and Krathwohl (2001) defined the levels of cognitive processes in the revised taxonomy and further organized them by specifying the appropriate subclasses. Remembering includes: Recognizing – Identifying; and Recalling – Retrieving. The level of Understanding includes: Interpreting – Clarifying, paraphrasing, representing, translating; Exemplifying – Illustrating, instantiating; Classifying – Categorizing, subsuming; Summarizing – Abstracting, generalizing; Inferring – Concluding, extrapolating, interpolating, predicting; Comparing – Contrasting, mapping, matching; and Explaining – Constructing models. Applying includes: Executing – Carrying out, and Implementing – Using. Within analyzing: Differentiating – Discriminating, distinguishing, focusing, selecting; Organizing – Finding coherence, integrating, structuring; and attributing – Deconstructing are arising. Evaluating includes: Checking – Coordinating, detecting, monitoring, testing; and Critiquing – Judging. Subclasses in the highest level of creating are: Generating – Hypothesizing; Planning – Designing; and Producing – Constructing.

The levels of revised Bloom's taxonomy of educational objectives in cognitive domain, with verbs that can be used for writing learning objectives are listed in the Figure 2.5.

Cognitive Domain Levels

-------------------------------- **Increasing Complexity** ------------------------------------>

	Remember	Understand	Apply	Analyze	Evaluate	Create
Definition	Retrieve relevant knowledge from long-term memory	Construct meaning from instructional messages, including oral, written, and graphic communication	Carry out or use a procedure in a given situation	Break material into its constituent parts and determine how the parts relate to one another and to an overall structure or purpose	Make judgments based on criteria and standards	Put elements together to form a coherent or functional whole; reorganize elements into a new pattern or structure
Verbs	Arrange Cite Choose Count Define Describe Duplicate Identify Label List Locate Match Name Outline Recall Recite Recognize Record Repeat Restate Review Select State	Abstract Associate Categorize Clarify Classify Compare Conclude Contrast Exemplify Explain Extrapolate Generalize Illustrate Infer Interpret Map Match Paraphrase Predict Represent Summarize Translate	Apply Carry out Demonstrate Determine Develop Employ Execute Implement Operate Show Sketch Solve Use	Analyze Attribute Deconstruct Differentiate Discriminate Distinguish Focus Organize Outline Parse Select Structure	Argue Assess Check Conclude Coordinate Criticize Critique Detect Evaluate Judge Justify Monitor Prioritize Rank Rate Recommend Test	Assemble Build Combine Compose Construct Create Design Draft Formulate Generate Hypothesize Integrate Plan Produce

Figure 2.5: *The levels of Bloom's taxonomy of educational objectives in cognitive domain (Retrieved from: https://www.emporia.edu/studentlife/learning-and-assessment/guide/domains.html)*

Blum's taxonomy is widely accepted and many authors point out its significance and different possibilities of its application. Taxonomy can be applied when one wants to develop appropriate teaching or learning strategies.

2.2. Metacognition

2.2.1. Concept of Metacognition

The term "meta" has a Greek origin ("among, with, after, change"). In English Dictionary one can find that prefix "meta" can be used with the meaning "beyond, or at higher level". It can be used to mean "about (its own category)", that is the way of use when one talks about metacognition.

In simple terms concept of metacognition refers to "cognition about cognition", "knowledge about knowledge", or "thinking about thinking" (Othman & Jaidi, 2012). According to various authors, wide range of metacognitive abilities includes:

- metacognitive knowledge (awareness of knowledge and processes of thinking and acquiring knowledge),
- metacognitive regulation (awareness of the need to use certain strategies, for instance planning, information management, monitoring, evaluation and debugging in the process of thinking and learning) and
- metacognitive experiences (for example, the tip of the tongue phenomenon).

Research in the field of metacognition deals with the problem of measuring metacognitive abilities, enhancing metacognitive abilities by different strategies and teaching methods, as well as examining the impact of metacognitive abilities on students' achievement and attitudes. Rahman (2011) suggests that researchers are trying to answer questions such as:
How does metacognition develop?
Can "teaching metacognition" enhance some positive change?
Does teaching metacognition lead to better regulation of cognitive activities?
Research in this field has been carried out since the 1960s and has roots in developmental psychology and cognitive psychology, where they are related to Hart's research of ("feeling of knowing experiences") (Miščević, 2006). Brown (1987) states that metacognition can be identified even in the analysis of the content and process of consciousness within introspective psychology, also in the term of executive of new cognitive psychology, in

conscious self-regulation in the context of Piaget's theory, and in the concept of social regulation in the theory given by Vigotski. Piaget was the first to use the terms “knowing the knowing and thinking the thinking”, related to early cognitive development (Piaget, 1950; according to Akturk & Sahin, 2011).

Knowledge of metacognition was originally formed in memory-related research (Flavell & Wellman, 1977). In his papers in the field of studying memory, Flavell first used the term metamemory, and afterwards the term metacognition with the meaning “knowledge and cognition about cognitive phenomena”, that is “thinking about thinking”. Since then, different meanings have been assigned to concept of metacognition.

Flavell (1976) stated that metacognition refers to individual’s knowledge related to his/her own cognitive processes and related activities and products. Besides, metacognition enables an individual to actively monitor and regulate his/her own cognitive processes usually in order to achieve a specific goal. Most researchers state that metacognition refers to individual’s thinking, as well as monitoring and control over thinking (Miščević, 2006). Since the beginning of the use of the term metacognition, various authors point out that its meaning is unambiguously defined (Forrest-Presley, MacKinnon & Waller, 1985; Hacker, 1998; Posner, 1989; Weinert, 1983). Zohar (1999) describes the difficulties of recognizing what belongs to the metacognitive domain and to distinguish different components of metacognitive knowledge. Numerous different categories of metacognitive phenomena illustrate how wide and diverse this concept is and point out to conceptual problems in trying to scientifically determine the notion of metacognition. Although all the authors found that it is possible to distinguish the concept metacognition from the concept of cognition, it is not always easy to distinguish between the two.

If a student knows that he/she is not good in physics, he/she can have problem either with metacognition or cognition. The difference can be made based on that how student understands and uses that fact about his/her learning difficulties.

Cognitive strategies are used to help a person to achieve a particular goal (for example, understanding the text), while metacognitive strategies are used in monitoring the process and controlling the achievement of this goal (for example, assessing the understanding of the text) (Kankaraš, 2004). According to Flavell (1976) metacognition and cognition differ in contents and function, and have similar form and quality. Cognition refers to concepts in the real world and mental images, while metacognition denotes knowledge, skills and information related to cognition, that is mental world (Gama, 2004). Similar relationship between these concepts is given by Noushad (2008). According to this author metacognition can be regarded as mediator between the learner and his/her cognition. Cognition and metacognition refer to the way learners' mind react on the "real world" and his/her cognition, respectively. This relationship is indicated in Figure 2.6.

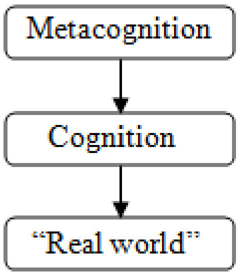

Figure 2.6: *The relationship between metacognition, cognition and the "real world" (Source: Noushad, 2008)*

Both cognition and metacognition can be correct or incorrect, adopted and forgotten. For example, textual material that is too greatly underlined and highlighted indicates that a student does not know how to recognize important information, and this indicates an inadequate metacognitive ability (Ganong, 2001). Veenman, Van Hout-Wolters & Afflerbach (2006) find that when it comes to the fact that metacognition can be incorrect, it relates to metacognitive knowledge. Metacognitive abilities in their opinion cannot be inaccurate, but may be underdeveloped and poorly applied. Even the unsuccessful application of metacognitive abilities can develop new metacognitive knowledge. This process of acquiring metacognitive abilities requires time and effort. Metacognitive activities can be used before cognitive activities (planning), during cognitive activity (monitoring) or after (evaluation) (Akturk & Sahin, 2011).

There are numerous definitions of the concept of metacognition, provided by various researchers in the field of cognitive psychology. Thus, for instance, Weinert and Kluwe (1987) determine metacognition as the activity of monitoring and control of cognition, i.e. cognitive abilities (Weinert & Kluwe, 1987). Similarly, Cross and Paris (1988) define metacognition as children's knowledge and control over their own activities during thinking and learning processes. According to Hennessey (1999) metacognition refers to individual's awareness of his/her own thinking and conceptions, refers to the tracking of cognitive processes, and finally to possibility to control cognitive processes due to further learning. Ormrod (2004) defines metacognition as knowledge about one's own cognitive processes and their use in learning or memorizing. According to Kuhn and Dean (2004) metacognition makes an individual aware of his/her own thoughts; and according to Martinez (2006) it enables a person to monitor and control thoughts.

Authors have developed different frameworks from categorizing metacognitive components (Table 2.2).

Table 2.2: *Typology of metacognitive components (Source: Lai, 2011)*

Metacognitive Component	Type	Terminology	Citation
Cognitive knowledge	Knowledge about oneself as a learner and factors affecting cognition	Person and task knowledge	Flavell, 1979
		Self-appraisal	Paris & Winograd, 1990
		Epistemological understanding	Kuhn & Dean, 2004
		Declarative knowledge	Cross & Paris, 1988 Schraw et al., 2006 Schraw & Moshman, 1995
	Awareness and management of cognition, including knowledge about strategies	Procedural knowledge	Cross & Paris, 1988 Kuhn & Dean, 2004 Schraw et al., 2006
		Strategy knowledge	Flavell, 1979
	Knowledge about why and when to use a given strategy	Conditional knowledge	Schraw et al., 2006
Cognitive regulation	Identification and selection of appropriate strategies and allocation of resources	Planning	Cross & Paris, 1988 Paris & Winograd, 1990 Schraw et al., 2006 Schraw & Moshman, 1995 Whitebread et al., 2009
	Attending to and being aware of comprehension and task performance	Monitoring or regulating	Cross & Paris, 1988 Paris & Winograd, 1990 Schraw et al., 2006 Schraw & Moshman, 1995 Whitebread et al., 2009
		Cognitive experiences	Flavell, 1979
	Assessing the processes and products of one's learning, and revisiting and revising learning goals	Evaluating	Cross & Paris, 1988 Paris & Winograd, 1990 Schraw et al., 2006 Schraw & Moshman, 1995 Whitebread et al., 2009

According to Flavell (1976) metacognition includes metacognitive knowledge, metacognitive experiences, tasks and goals, as well as strategies and actions. In addition to metacognitive experiences such as the feeling of confusion, impression that the error occured and similar, Brown (1978) distinguishes two metacognitive activities: knowledge of cognition and activities that are used for monitoring and managing cognition. Kluwe (1982) identified declarative and procedural knowledge, as well as Chi (1987). Blakey and Spence (1990) identified the three steps in the metacognitive process: (1) linking new information and prior knowledge, (2) selecting the appropriate thinking strategy, and (3) planning, monitoring, and evaluating thinking process (Figure 2.7).

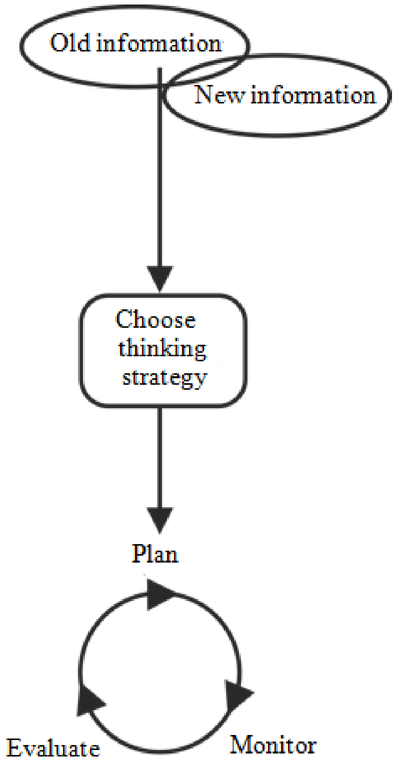

Figure 2.7: *Three steps in metacognition (Source: Blakey and Spence, 1990; according to Rahman, 2011)*

Similarly, Hunt and Ellis (2004) described three aspects of metacognition: (1) knowledge, (2) monitoring, and (3) control. Sternberg (1991) developed the triarchic theory of intelligence within which next executive processes are suggested as metacomponents: planning, evaluating and monitoring problem-solving activities. According to Lefrancois (1988), “Sternberg described nine different metacognitive strategies: problem identification, selecting a process of problem solving, strategy selection, selecting a mode of representation (e.g.;

diagrams, tables, outlines), allocation of resources, monitoring progress, sensitivity to feedback, incorporating feedback, and implementing selected strategies." According to Wilson (1998), there are three metacognitive functions: (1) awareness, (2) evaluation, and (3) the regulation. As different definitions of the concept have been given by different authors, they have also given suggestions for different classification of metacognitive sub-categories.

Based on the above, the awareness of metacognition can be categorized into: metacognitive knowledge, metacognitive regulation, and metacognitive experiences. Knowledge of cognitive processes includes three different types of metacognitive awareness (components of metacognition) (Schraw & Moshman, 1995; Woolfolk, 1998): (1) declarative knowledge, (2) procedural knowledge, and (3) conditional (strategic) knowledge. Declarative knowledge refers to how to do something. Procedural knowledge covers the skills, strategies and resources required to perform the task (knowledge of how to perform something). Conditional knowledge is knowledge of when to apply a certain strategy. Metacognitive regulation refers to the awareness of the need to use certain strategies, such as planning, information management, monitoring, evaluation and debugging in the process of thinking and learning (Kluwe, 1987; Schraw & Dennison, 1994). Metacognitive experiences represent the feelings, estimates or judgments related to the features of the learning task, the cognitive processing as it takes place, or of its outcome. For example, the tip of the tongue phenomenon is very common. These experiences are subjective feelings related to monitoring one's own knowledge (Koriat & Levy-Sadot, 1999). Nelson and Narens (1994) suggested three categories of monitoring judgements: (1) Easy-of-learning (EOL), (2) Judgements of learning (JOL), and (3) Feeling-of-knowing (FOK); these feelings occur before, during and after learning, respectively. According to Efklides (2009), the critical feature of metacognitive experiences is their affective character.

It can be concluded that various authors propose different metacognitive models, three widely accepted models are proposed by Flawell, Brown, and Nelson and Narens.

Flavell proposed "a model of metacognition and cognitive monitoring in describing: metacognitive knowledge, metacognitive experience, goals or tasks and actions or strategies" (Rahman, 2011). This model is illustrated in Figure 2.8. Papaleontiou-Louca (2003) explained that "goals refer to the objectives of a cognitive enterprise, and actions refer to the cognitions or other behaviors employed to achieve them."

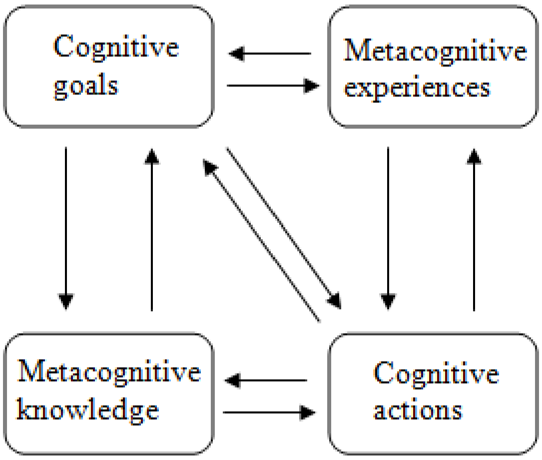

Figure 2.8: *A model of cognitive monitoring (Source: Flavell, 1976; according to Papaleontiou-Louca, 2003)*

According to Brown (1987) metacognition includes: knowledge of cognition and regulation of cognition. Brown's model of metacognition is illustrated in Figure 2.9.

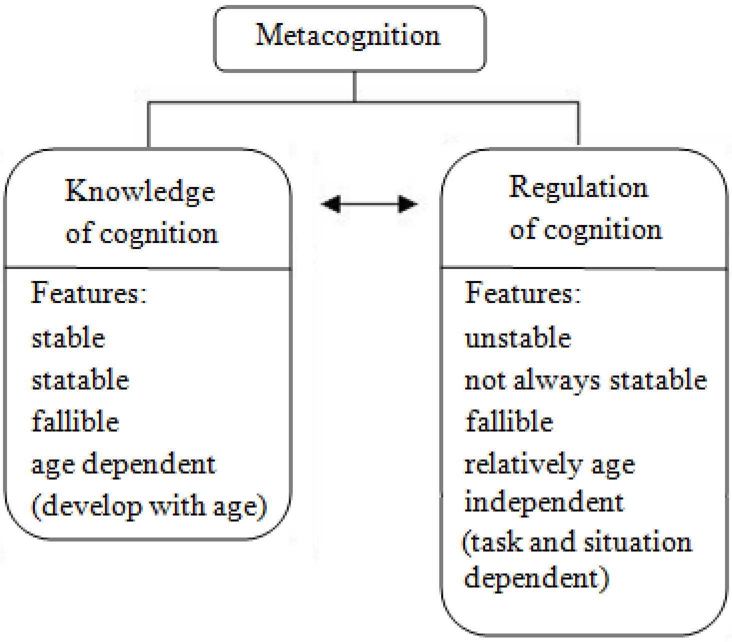

Figure 2.9: *Brown's model of metacognition (Source: Brown, 1987; according to Gama, 2004)*

Nelson and Narens (1990; according to Shimamura, 2000) have distinguished two aspects: (1) metacognitive monitoring and (2) control. According to their characterization of these aspects, illustrated in Figure 2.10, metacognition is understood as a mediator between object-level information and meta-level.

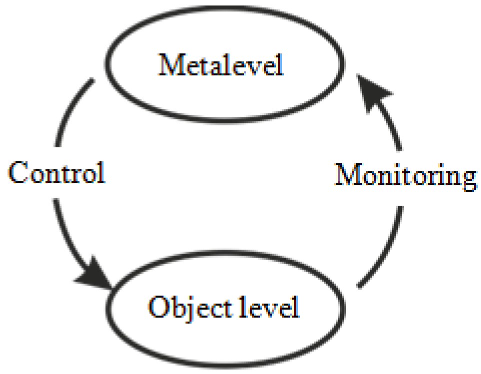

Figure 2.10: *Metacognitive model (Source: Nelson & Narens, 1990; according to Rahman, 2011)*

Various terms related to metacognition are used to indicate concepts that partially coincide. Hunt and Ellis (2004) consider that the prefix "meta" can be found with the terms related to all cognitive process (or ability) and, for example, there is metalanguage and metacomprehension. The terms closely associated with the concept of metacognition, slightly different and less comprehensive, which are used in the field of cognitive psychology, are metamemory, metacomprehension, and calibration of comprehension. Metamemory refers to the knowledge and comprehension about one's own memory, and about memory in general (Schraw, 2009). Maki (1998) uses the term metacomprehension to describe the process of learning from the text. According to Lin and Zabrucky (1998) calibration of comprehension is "the relation between students' confidence and performance or between predicted and actual performance"; it is used for estimation of accuracy of self-assessing comprehension.

2.2.2. The Importance of Metacognition

Views posed by psychologists who have studied thought processes indicate the importance of metacognition in both the learning process and in the overall development of personality. Within metacognition, Weinert (1983) differs: evaluation, which involves identifying problems, and regulation. An example of an evaluation is when a student realizes that he/she does not understand something, and an example of regulation is when he/she takes measures to increase understanding (learning more or using different learning strategies). Metacognitive skills enable the monitoring of progress in learning (Lefrancois, 1988). By means of metacognitive skills, the result of the effort can be estimated and the probability of a satisfactory remembering of the mastered material can be predicted. Rivers (Rivers, 2001, according to Rahman, 2011) identifies two types of metacognitive abilities: selfassessment and selfmanagement. Osman and Hannafin (1992) state that aspects of metacognition are: metamemory, metacomprehension, selfregulation, schema training and transfer. The schema training implies the development of cognitive structures that provide a conceptual framework for comprehension (Gordon & Braun, 1985). Transfer is necessary for gaining independence and autonomy. It refers to the application of mastered strategies to different tasks, problems, or in different situations (Osman & Hannafin, 1992).

Understanding the concept of metacognition can give answers to questions related to development in the cognitive and affective domains, but it can also improve understanding and analysis in all areas where the selfregulation process is involved. Metacognition is, therefore, of very high value. Psychologists and pedagogues are aware of the importance of selfevaluation of comprehension with the aim of adapting the activities while learning (Brown, 1987). Learning involves various selfregulation processes, such as planning, monitoring, regulation (Azevedo, 2009).

According to Mirkov (2006), the research results about metacognition can be useful in improving the education because the understanding of metacognition in a teaching context is of particular importance for problem solving, generalization and transfer in learning. Besides, developing the ability of regulating the learning process is increasingly emphasized as an important educational goal.

Metacognition is very important for problem solving (Gardner, 1991, according to Lee, Teo & Bergin, 2009). Enhancing metacognition can contribute in overcoming everyday-life problems and decision-making, and also for dealing with unusual problems (Lee, Teo & Bergin, 2009). It helps individuals to: (1) recognize that there is a problem to be solved, (2) understand the nature of the problem, and (3) understand how to solve it (Davidson, Deuser & Sternberg, 1994). According to Sternberg (1991), the ability to quickly and effectively opt for a method necesarry to solve a problem, is reflected in components of metacognition.

Ahmadi, Hairul and Abdullah (2013) stated that “metacognition is an important aspect of students’ learning; it helps students learn the material more efficiently, retain knowledge longer and generalize skills“. It enables students to solve new problems by retrieving the strategy that they have successfully used in a similar context (Kuhn & Dean, 2004). Students with highly developed metacognition are convinced that they can learn, they take some time to reflect on their learning and they are accurate when evaluating their success in learning. They think about the errors that have occurred while they were performing tasks, and they are successful in connecting and adjusting learning strategies to the tasks at hand (Rahman, Jumani, Chaudry, Chisti & Abbasi, 2010). Although it is known that metacognitive strategies help improve students’ metacognition, they are not included in today’s school practice due to inadequate resources and a lack of opportunity for professional development.

Based on the various studies, the authors imply that the introduction of metacognitive strategies into the teaching process would contribute to the efficiency of teaching (Fouché & Lamport, 2011). According to Kuhn & Dean (2004) metacognition is a bridge between cognitive psychology and educational practice. Metacognition is essential for successful learning, because it allows the individual to better manage his/her cognitive skills, as well as to see his/her weaknesses and how he/she can correct them by developing appropriate new cognitive skills (Schraw, 1998). Biggs (1985) suggested the application of metacognitive processes to school learning. Besides, for this precisely targeted and specialized application of metacognition, he introduced the term metalearning. Metalearning refers to students' awareness of their own motives for learning and control over selection and the use of learning strategies. First, the individual becomes aware of what he/she wants to achieve by learning, and then, at a stage that is normally attainable in the final grades of the primary school, in accordance with the set goal, he/she decides on the appropriate learning strategy. While examining the development of metacognitive skills in children and adolescents, Schneider (2008) comes to the conclusion that the understanding of metacognition brings significant implications for school practice. According to him, declaratively metacognitive knowledge in adolescence can be linked to the theory of mind in the earliest childhood.

Students who do not have a good metacognitive approach, learn without assessing their progress and achievements without clear future direction (O’Malley, Russo, Chamot, Stewner-Manzanares & Kupper, 1985). Pressley, Synder and Cariglia (1987) stated that metacognition helps students to be aware of their learning, to understand the situations in which they will benefit from it and be aware of the processes they are using for acquiring knowledge. Young children do not have the possibility of a complex learning, but not because of absence of cognitive abilities, but because of the lack of metacognitive abilities (Siegler, 1978; according to Brown, 1984). Mirkov (2005) states that different approaches can help in developing thinking and problem solving in schools (approaches can be related to the knowledge specific for given subject or the metacognitive processes). Consequently, it is necessary to overcome the gap between programs aimed at developing thinking and teaching subject contents.

The inclusion of metacognitive components in the teaching process is related to psychosocial learning outcomes, such as motivation or self-evaluation (McInerney, McInerney & Marsh, 1997). Hong and O'Neil (2001) conducted a study in which they obtained the evidence of correlation of metacognitive and motivational components of selfregulation.

Sometimes students do not invest the necessary effort in learning because they believe that intellectual ability, especially its lack, makes effort unnecessarily (Mirkov, 2006). The motivation theories are directed to these and similar problems.

The theory of selfefficiency (Bandura, 1997) is a motivational theory that is based on the phenomena closely related to concept of metacognition. Successful students attribute success to the factors that they control themselves, such as their effort and the use of certain strategies. Accordingly, they are persistent even when they encounter difficulties in learning. A student who has knowledge of how to remember the requested information will not apply it if he/she believes that he/she cannot control success in performing the task (regulatory metacognitive skills). Often, students do not have a sufficiently developed experience of selfefficiency, and often there is a lack of motivation to carry out academic tasks (Mirkov, 2006).

Kleitman and Stankov (2005, 2007) showed that the factor of metacognitive awareness correlates with the factor of self-confidence. They concluded that self-confidence is a component of metacognition. Stankov (2000), in addition to self-confidence, also considers self-assessment. Self-confidence can be noticed while answering, and the self-assessment is carried out after testing by indicating the likely number of correct answers.

Weak students may benefit more from metacognitive activities than good students (White & Frederiksen, 1998). Appropriate instructions encourage the development of metacognition, which is reflected in students' performance (more pronounced in weaker students' performance) (Zohar & David, 2008). Borkowski, Estrada, Milstead and Hale (1989) after pointing to the connection of the problem solving skills and metacognition, illustrate the approach to teaching students with learning disabilities based on it.

Metacognition is a key concept for understanding the relationship between cognition and motivation (McCombs & Marzano, 1990) and it plays a key role in the individual's self-awareness that contributes to the encouragement of the will and motivation to engage in the regulationt of the learning process. Student attitudes and the level of metacognitive skills are related to finding the best approach, which results in an optimal understanding of the text (Khonamri, 2009).

Swanson (1990) indicated that great importance of metacognitive abilities can easily be emphasized by stating that children with highly developed metacognitive abilities solve problems more efficiently than children with low level of metacognitive abilities (even in the case when the latter are more gifted). Zimmerman and Martinez-Pons (1990) have shown that gifted students more often use learning strategies that involve self-regulation, for example, organizing information, transforming information, seeking peer help, reviewing notes, than average students.

According to Rahman (2011), the researchers in the North Central Regional Educational Laboratory reported to be convinced that learner with highly developed metacognition will most likely: (a) be confident in his/her ability to learn, (b) make exact judgment of his/her success in learning, (c) think about mistakes that occur during tasks, (d) actively expand collection of strategies for learning, (e) match strategies to the learning task and make necessary adjustments, (f) ask peers or teacher for advice, (g) take time to think about his/her thinking, (h) view him-/herself as learner and thinker.

It may be summed up that metacognition is important as it helps students to recognize the need to adapt their learning activities according to the demands of task. It provides learners the information necessary to design their own learning plans. It shifts the responsibility from teachers to students and produces more independent learners. It helps students in developing the ability to monitor and regulate their cognitive activities while learning, and performs several other functions.

The significance of metacognition is reflected in various facts. Metacognition improves: problem solving; learning; self-regulation; academic achievement; reflective thinking and self-confidence for making decisions; critical and creative thinking (Memnun & Akkaya, 2009; according to Mai, 2015). According to Rahman (2011) metacognition includes: (1) connecting new information with prior knowledge, (2) consciously selecting appropriate strategy, and (3) planning, monitoring, and evaluation of thinking. Mai (2015) stated that metacognitive skills help individuals "in the process of identifying the structure of problems, creating connections with prior knowledge, and selecting learning strategies."

Various studies have shown that metacognition has positive impact on learning different disciplines, for example: language (Hauck, 2005; Oxford, Lavine & Crookall, 1989), mathematics (Garofalo & Lester, Jr., 1985), sciences (Kuhn, 1989).

Metacognition in the teaching of natural sciences includes two aspects: learning to develop metacognition and learning with the use of metacognitive abilities. Metacognition is a predictor of learning and allows students to work independently and flexibly (Rahman, 2011).

Metacognitive strategies help learners identify specific learning objectives, filter new information, and retrieve relevant information to fill in gaps in their knowledge (Pichert & Anderson, 1977). The use of metacognitive strategies, especially those involving planning and evaluation, develops students' critical thinking (Ku & Ho, 2010). In order to effectively control his/her own acquisition of knowledge, precise metacognitive assessments and selection of appropriate learning methods are necessary for an individual (Metcalfe, 2009).

Several studies indicated the importance of metacognition for learning physics. It is shown that the use of appropriate metacognitive strategy enhances students' performance in physics (Akyüz, 2004; Bogdanović, Obadović, Cvjetićanin, Segedinac & Budić, 2015). Gok (2010) states that the use of different strategies for solving problems in teaching physics can contribute to the students' success in mastering the physics contents, and the inclusion of metacognitive abilities, such as planning, monitoring, evaluation, additionally contributes to increasing students' performance. From the significance of selfregulation in solving physics problems, arrives the necessity for teaching metacognitive skills within teaching contents

(Çaliskan & Selçuk, 2010). Koch (2001) points to the importance of the appropriate metacognitive tasks that help students to better understand texts in the field of physics.

2.2.3. The Development of Metacognition

While one teaches students, he/she should help them to acquire knowledge and also to develop skills to think and learn on their own (Cromley, 2000). Traditional teaching method does not enhance thinking process or the use of metacognitive strategies (Cadle, 2010). Teacher's instruction based on metacognitive strategies helps students to define learning goals and to monitor their progress during learning process. In that way students are enabled to take control over their own learning (Bransford, Brown & Cocking, 2000). Because of that, teaching should enable the adoption of appropriate content, but also encourage the development of metacognition. One way to achieve this is to follow the four principles (Lin, 2001): (1) provide frequent opportunities for students to assess what they know and what they do not know, (2) help students to express their opinions, (2) encourage students to understand the goals of metacognitive activities; and (4) developing the knowledge and experience of an individual about himself as a student with respect to cultural differences.

Numerous attempts have been made to identify variables that may affect metacognition. According to Flavell (1979), metacognition depends on three variables: student, task, and strategy. There are developed metacognitive instructions that systematically promote metacognition.

Hartman and Sternberg (1993) specified four ways of developing metacognition within school hours: (1) developing awareness of the importance of metacognition; (2) developing cognitive knowledge, (3) developing regulation of cognitive processes; and (4) fostering an environment that encourages the development of metacognitive awareness. Another approach to this problem, points to four ways in which students can develop metacognitive abilities (Paris & Winograd, 1990; according to Aydin, 2011): (1) direct teaching of metacognitive abilities, (2) teaching metacognitive abilities within the content of the teaching subject, (3) teaching metacognitive strategies with the use of different strategies and techniques by experts, and (4) teaching metacognitive strategies by cooperative learning techniques.

Metacognitive abilities develop through the experience an individual acquires throughout life, but also through experiences related to specific tasks. Developing planning skills is most prominent among younger students and is largely under the influence of repetition, or gaining experience on specific tasks (Krätzig & Arbuthnott, 2009). Roll, Aleven, McLaren and Koedinger (2007) developed the principles of teaching about seeking help in learning.

Gama (2004) states that appropriate metacognitive abilities are used automatically and unconsciously, and that metacognitive strategies are conscious, planned use of a particular method. After identifying metacognitive abilities and strategies by providing a clear boundary between them, Gama raises questions about:

- Whether metacognitive abilities can be learned; if they are not automatically processes of the individual;
- Whether they have been trained through formal education or through acquired experience and then automated; and
- Whether they can be developed using strategies.

Young learners (aged 3 to 5) are encouraged to engage in metacognitive and self-regulatory activities with peer-assisted learning (Whitebread, Bingham, Grau, Pasternak, & Sangster, 2007).

Miščević (2005) in her paper shows that the application of problem based learning, in contents related to nature, led to an increase in the level of metacognitive activities of students. According to the findings given by Miščević (2006) problem based learning contributes to the greater presence of planning activities in relation to traditional teaching. Haryani, Masfufah, Wijayati1 and Kurniawan (2018) carried out research that included high school students in Indonesia. They suggested that the steps in the problem-based learning affect the metacognitive skills and can lead learners to develop their reasoning skills in the solving problems.

The teacher should teach students about self-assessment and instruct them to evaluate their own performance and to think of ways to improve it. Self-evaluation is different from self-assessment because it allows students to have impact on their marks (Andrade, 2007). Thirtle (2014) investigated self-assessment in learning and she stated that active feedback strategies enhance students' performance and metacognition.

Van de Kamp, Admiraal, Van Drie, and Rijlaarsdam (2015) proposed explicit instruction of metacognition in Visual arts education. Karaali (2015) gave example how to incorporate metacognition in teaching mathematics. He proposed that each student should weekly evaluate his/her own progress.

Increasing metacognitive awareness and encouraging metacognitive regulation should be important developmental and educational objectives (Kuhn, 2000).

2.3. Know-Want-Learn Strategy and Its Modifications

2.3.1. Know-Want-Learn Strategy

The Know-Want-Learn (KWL) strategy is initially developed as a learning strategy for guiding students through a text. It was first suggested by Ogle (1986). Since originally it was a reading strategy, it was rarely applied in teaching physics and science in general. However, it turned to be a simple and effective strategy that can be applicable in different school subjects (Foote, Vermette & Battaglia 2001). The use of the KWL strategy supports active learning and student-centered learning (Bryan, 1998; Ogle, 2009). This strategy consists of three phases where students: (1) activate prior knowledge, (2) determine what they want to know and (3) reflect and recall on the new knowledge (Blachowicz & Ogle, 2008).

This strategy suggests the use of the KWL charts, which are the graphic organizers that help students to organize information, before, during, and after a unit or a lesson. The use of the KWL charts successfully inspires students' inquiry (Ogle, 2009). These charts help students not only to adopt given concepts but also to activate their prior knowledge (Martorella, Beal & Bolick, 2005). Many studies have shown that activating prior knowledge is a mean to support students' reading comprehension (Riswanto, Risnawati & Lismayanti, 2014). Such KWL charts consist of three columns: *K – What I Know*, *W – What I Want to know* and *L – What I Learned* (Figure 2.11). When they are used in the schools, the KWL charts can be applied through four students' activities: (1) brainstorming about what they already know about a topic and listing responses in the first column of the chart; (2) brainstorming about what they would like to know about the topic and writing responses in the second column of the chart; (3) reading and learning and (4) filling what they have learned in the third column of the chart with special attention to the information that is related to what they wanted to know. This strategy can be used by a teacher working with all students in the classroom or it can be used by students for their independent study (Tok, 2013).

What I Know	What I Want to know	What I Learned

Topic:

Before you begin learning, list details in the first column. After completing it, fill in the last column.

Figure 2.11: *The KWL chart*

The students who use the KWL strategy can easier establish the purpose of reading and develop skills for monitoring their comprehension (Szabo, 2006). The KWL strategy promotes active learning and encourages academic success (Tran, 2015) and increases reading comprehension (Al-Khateeb & Idrees, 2010). Moreover, it makes learning and remembering easier and, since each student is studying questions in which he/she is specially interested in, the understanding of content is improved in this way (Gammill, 2006). Accordingly, the KWL strategy can be used for acquiring physics contents.

Research results of various studies showed an increase in students' performance after the implementation of the KWL strategy when learning different teaching contents (Al-Khateeb & Idrees, 2010; Brozo & Simpson, 1991; Foote, Vermette & Battaglia 2001; Gammill, 2006; Zouhor, Bogdanović, & Segedinac, 2016). Also, numerous studies indicate that the application of this strategy encourages the development of metacognition (Gammill, 2006; Mclain, 1993; Mok, Lung, Cheng, Cheung & Ng, 2006; Ogle, 2005; Szabo, 2006; Tok, 2013).

The KWL strategy is based on constructivism (Dammani, 2012), explicitly to Ausubel's assimilation theory of learning. Accordingly, by its use new concepts are added to the already existing system of knowledge (Ausubel, Novak & Hanesian, 1978).

2.3.1.1. The Importance of Prior Knowledge (K Column)

The K column of the chart is important because it induces activation of students' prior knowledge. This column provides an opportunity for the teacher to get insight into students' prior knowledge, as well as to get information about students' interests in the topic. Besides, significant information that the teacher can obtain from this column is information about misconceptions that students had before beginning the teaching unit. Milenković, Hrin, Segedinac and Horvat (2016) stated that it is very important to identify students' misconceptions since they are barriers to learning.

Various studies identified the significance of students' prior knowledge and the ability to activate this knowledge within the learning process (Ausubel, 1968; Beck, Omanson, & McKeown, 1982; Gillani, 2003). Student's prior knowledge significantly influences the further reorganization of his/her individual cognitive structure (Taboaga & Guthrie, 2006). In addition to identifying prior knowledge, it is important that "the relationship between what is known and what can be known" is understood. In accordance with the above, the importance of the Ausubel's (1968) theory can be pointed out. Constructivist principles are the basis of this theory. According to the constructivist theory (Bodner, 1986, 2001), students construct knowledge from their own experiences, by applying appropriate learning strategies (Zhao, Wardeska, McGuire & Cook, 2014). Moreover, they are able to learn new and advanced learning strategies within their interaction with the environment (Hess & Trexler, 2005). Resnick (1984) defined comprehension as a mental process in which student actively "uses external information" in order to construct new knowledge. The formation of the concept begins with students accessing their own system of previously stored information (Lipson, & Wixson, 1991), which was named "prior knowledge" (Ausubel, 1968; Anderson, 1977; Gagne, 1985). Then this process proceeds in such a way that each student selects particular information from that system, based on the relevance of this information. Rumelhart (1977) gave description of this interaction ("interchange") between student, his/her prior knowledge and new knowledge within the scheme theory. Besides, it is related to the general theory of knowledge and memory (Maria, 1990).

2.3.1.2. The Importance of Students' Interest (W Column)

According to Dewey (1913) being interested means "being engaged, engrossed, or entirely taken up with an activity, object, or topic." A number of studies have shown that there is a positive correlation between students' interest and performance (Ainley, Hidi, & Berndorff, 1999, 2002; Harackiewicz & Hulleman, 2010; Schiefele, Krapp, & Winteler, 1992) and while writing in the W column of the chart, students' interest for given topic increases.

Various studies have indicated that interest strongly impacts on how one functions, in both cognitive and affective domain (Renninger, 2000; Renninger & Wozniak, 1985; Schiefele, 1996; Schiefele, Krapp, & Winteler, 1992). Besides, high interest implies that students will focus their attention and stay persistent in learning. Interest can be considered as individual’s predisposition as well as a psychological state (Ainley, Hidi, & Berndorff, 1999). According to Ainley, Hidi, & Berndorff (2002) “the relationship between interest and learning has focused on three types of interest: individual, situational, and topic”, which are personal, environmental and contents related, respectively. Topic related interest can be considered as dependent on both, personal and environmental factors (Ainley, Hidi, & Berndorff, 1999). In school learning, teacher has impact on environmental factors, mostly with implementing different strategies and various organisations and presentations of tasks. Interest is important for learning because it promotes students’ attention and persistence, which enhance learning and, therefore is reflected in better students’ performance.

2.3.1.3. The Importance of Summary (L Column)

When one finishes learning, it can be useful to review and analyse main concepts. In the L column of the chart, each student records a summary of what he/she has learned. Besides, students’ misconceptions can be identified and revised by students themselves. The instruction that students have in relation to this column, directs them to perform metacognitive activities. Students are instructed to think of their new knowledge and self-evaluate their learning.

According to Khoshnevis and Parvinnejad (2015), Chastain (1988) stated that “post-reading activities help readers to clarify any unclear meaning where the focus is on the meaning not on summarization as a kind of post-reading activity where the readers are asked to summarize the content in a sentence or two”. Students who are able to identify the main idea in the content they have learned, that is, to summarize given material, are successful learners (Jones, 2006). The importance of promoting students’ metacognition is indicated earlier.

2.3.2. Modifications of KWL Strategy

Modified KWL strategies can be developed in order to adjust charts for different students’ activities. One of the earliest modifications of the KWL strategy is the KWL Plus. In this modification, concept mapping and summarizing of learned content is added to the original strategy (Ogle, 1987). Concept mapping is applied because this strategy is based on Ausubel's assimilation theory of learning and adding new concepts to an existing knowledge system (Stanisavljević & Stanisavljević, 2017; Stanisavljević, Bunijevac & Stanisavljević, 2017).

One of the simplest modifications of the KWL strategy is the KWLH chart, where additional H stands for How can I learn more. With this additional column students are encouraged to think of the possible ways of expanding their knowledge and hence the future learning is supported (Weaver, 1994). Walker Tileston (2004) indicated that the KWLH strategy is an effective teaching strategy. Cavner (2013) discussed strategies for preparing children in early childhood education programs to learn about new topics and found that the KWLH is supporting the organization of new information. Sumardiono (2013) suggested using the KWLH strategy to understand local descriptive texts in teaching reading.

*What I **K**now*	*What I **W**ant to know*	*What I **L**earned*	***H**ow can I learn more*

*What I **T**hink about a topic*	*What else I **W**ant to know*	*What I **L**earned*

*What do you **T**hink*	***H**ow can we find out*	*What do we **C**onclude*

Figure 2.12: *Different charts used in modified KWL strategies: KWLH, TWL and THC*

Various columns can be found in different modifications of KWL strategy (Figure 2.12), one variation with additional instruction is shown in Figure 2.13.

Figure 2.13: *KWHLAQ chart (Retrieved from: www.globallyconnectedlearning.com)*

Teachers at Colorado Springs, School district 11, found that New KWL concept map (Figure 2.14) is highly effective instructional strategy (2011).

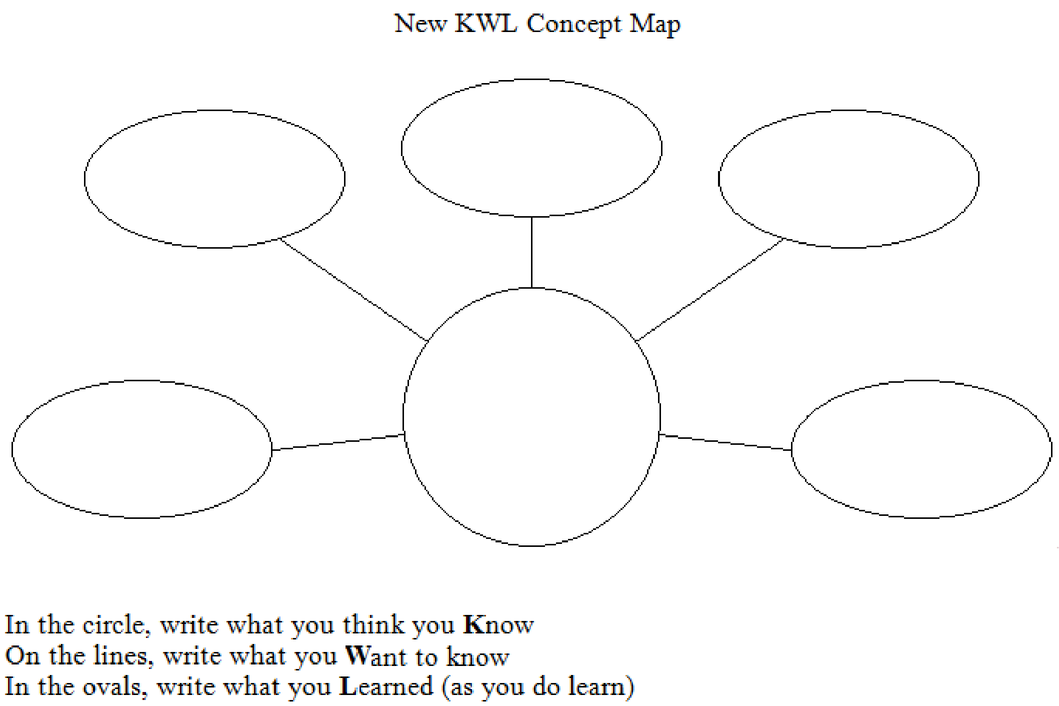

Figure 2.14: *The new KWL concept map*

Another modification of the KWL strategy is TWL, where T stands for What I Think about a topic. When the T column replaces the H column, the strategy is more useful for learning sciences, it supports inquiry and investigation (Akerson, 2001). The first column of the TWL chart encourages students to think and discuss about the problem. The students who use this strategy are encouraged to think to a great extent. The W stands for What else I Want to know and it enables proposing questions and formulating hypotheses for inquiry.

The THC strategy expands on above-mentioned strategies. It is suggested by Crowther and Cannon (2004) as a useful strategy that helps students to think about scientific research and propose hypotheses. The use of this strategy trains students to think as scientists; students ask questions, choose methods for their inquiry and evaluate the results of their work. Crowther and Cannon note that the first column T – What do you Think is encouraging students to freely share their ideas. In the next column H – How can we find out students think of ideas that may lead to different ways of inquiry. After the inquiry process is completed, students should be able to draw conclusion about a given content and write it in the column C – What do we Conclude. The teacher can guide the students to conclusions by appropriate questions. Nevertheless, the teacher gets the opportunity to monitor the progress of each student based on student’s conclusion, and therefore to evaluate students’ understanding of a teaching unit (Crowther & Cannon, 2004).

The KLEW(S) strategy is another modification of the KWL strategy. In this adaptation for science teaching (Hershberger, Zembal-Saul & Starr, 2006; Hershberger & Zembal-Saul, 2015), the components of chart are used to document the following: K – What do we think we Know, L – What are we Learning (claims), E – What is our Evidence, W – What do we still Wonder about and S – What Scientific principles help explain the phenomena.

For successful physics text comprehension and solving tasks in order to strengthen critical thinking, Sumardiono (2014) suggested the effective strategy in the form of the KNWS chart that consists of four columns: K – Know the information, N – Not relevant, W – Want to find and S – Strategy used.

The mKWL strategy used in this research consists of learning with the help of TQHL chart. This choice was made since authors realized that the TQHL chart appeared to be very convenient as a tool during the physics classes, due to the fact that it encourages students' learning and inquiry.

Although different charts (THC, KLEW, KNWS) appeared to be very well adjusted for the scientific inquiry, it seemed more convenient to make new adjustments of chart for the students included in this research. The idea was to activate students' prior knowledge but also to allow and encourage them to present their own thoughts. Because of that the first column covers both, Know and Think – What I Think and what I know. It is followed by the column What Questions I have, so the students can propose problem and hypotheses for an inquiry. Further on students should think of different ways of how to come to answers and hence write their ideas in column How can I find out. They can propose hands-on activities, learning from books, an inquiry process and other, and the teacher can lead them to choose different methods. In the last column What I Learned the students write about knowledge they gained.

3. Methodology of Research

3.1. Research Problem

Physics is generally regarded as difficult and uninteresting subject. Due to this fact, a number of average primary school students achieve low performance in physics. Therefore, physics teachers should find the way to help students to better acquire physics contents and that should result in better students' performance.

It is shown that different teaching strategies can help students in learning physics contents but there is no strategy that can be regarded as the best. It is helpful to find various strategies appropriate to use in physics class to encourage students' learning and inquiry. In that way the teacher can decide which strategy will fit best in certain conditions, depending on the teaching contents, structure of the class and teacher's personal affinity. Different modifications of the KWL strategy are examined as a tool for teaching various academic disciplines. In this research, the KWL strategy was adjusted such that the proposed modification can be a useful strategy for teaching physics. Besides, the proposed modification of the KWL strategy can be used for promoting students' metacognition.

3.2. The aim of Research, Research Hypotheses and Research Questions

The research was carried out with the aim to examine the effect of the mKWL strategy on primary school students' performance in physics and metacognition. Additionally, the gender differences in students' performance and metacognition, as well as the relationship between students' performance and metacognition, are examined.

From the stated aim of research, the following research questions arise:

- Does using the mKWL strategy have a positive effect on sixth-grade students' performance in physics (which means that this strategy increases sixth-grade students' performance in physics)?

- Does students' performance in physics depend on gender?
- Does using the mKWL strategy have a positive effect on sixth-grade students' metacognition?
- Does students' metacognition depend on gender?
- Is there correlation between the students' metacognition and the students' performance in physics?

In accordance with the given theoretical framework and research questions, the following research hypotheses were formulated:

1. There is no significant difference between the pre-test score in the physics knowledge test (PKTi score) and the post-test score in the physics knowledge test (PKTf score) for the group of students who were taught traditionally (group C).
2. There is a significant difference between the PKTi score and the PKTf score for the group of students who were taught by using mKWL strategy (group E).
3. There is a significant difference in the PKTf scores between the students in groups E and C, in favour of group E.
4. There is no significant difference between the PKTi scores between the male and female students.
5. There is no significant difference between the PKTf scores between the male and female students.
6. There is no significant difference between the pre-test score in the questionnaire on metacognition (QMi score) and the post-test score in the questionnaire on metacognition (QMf score) for the students in group C.
7. There is a significant difference between the QMi score and the QMf score for the students in group E.

8. There is a significant difference in the QMf scores between the students in groups E and C, in favour of group E.

9. There is a significant difference between the QMi scores between the male and female students.

10. There is a significant difference between the QMf scores between the male and female students.

11. There is a significant positive correlation between the PKTi score and the QMi score.

12. There is a significant positive correlation between the PKTf score and the QMf score.

3.3. Research Methods

The following methods were applied in the research: analytical method, pedagogical experiment method and statistical method. The prior knowledge about the research topic and relevant literature were analyzed. Special attention was focused on the analysis of the various proposals and examples of implementation of the KWL strategy and its modifications in different academic disciplines. Quasi-experimental pre-test – post-test research was designed in order to achieve the set research aim. A pedagogical experiment with parallel groups – experimental and control was applied. In order to confirm proposed hypotheses, statistical analysis of the obtained data was performed. The statistical analysis will be described in detail.

3.4. Research Sample

The total number of students participating in this research was 141 (five different classes). They all were enrolled in the sixth grade of a primary school in Subotica, Republic of Serbia. Although five classes were pre-tested to enable choosing the suitable (experimental) group E and (control) group C, four classes are chosen for further research. After the pre-test was implemented, the experimental research was carried out with 110 sixth-grade students (51 boys and 59 girls) from four classes. The research was carried out respecting the ethical standards and all students were voluntarily participating in the research and their privacy is respected.

The KWL strategy and its modifications are not being used by Serbian teachers. Hence, selected primary school was convenient because physics teacher employed there was prepared to be trained for implementing the TQHL charts in physics class. The teacher took an active part in preparing the material and has done necessary preparation in order to use this teaching strategy. Researcher wanted to eliminate a possible influence of imposing substitute teacher to the group of students, hence the sample size was limited by the number of sixth-grade students taught by the teacher (trained for implementing the TQHL charts). There were 54 students in group C and 56 students in group E. Used sample is valid for all tests performed in this research.

The structure of the respondents according to their overall success at the end of the fifth grade was as follows: 61.82% Excellent; 30.91% Very good; 7.27% Good; there were no students with Fair and Poor success. Based on this, one can express concern that marks are not a measure of students' knowledge and that in some primary schools students can easily achieve good success.

3.5. Design and Procedure

The quasi-experimental research was carried out in order to examine the effect of the used mKWL strategy on primary school students’ performance in physics. The research was carried out for 14 school weeks (from the beginning of March to the end of June) during the school year 2015-2016. The research design of the main study is shown in Figure 3.1.

The main study was preceded by a pilot study with the same research design, which was carried out during the school year 2014-2015. The pilot study was used to detect unexpected problems in carrying out research such that researchers could be prepared for them. Moreover, it enabled researchers to check students’ understanding of test items in constructed research instruments (questionnaire on metacognition, pre-test and post-test). The research sample that was used in the pilot study consisted of 59 students from two sixth-grade classes.

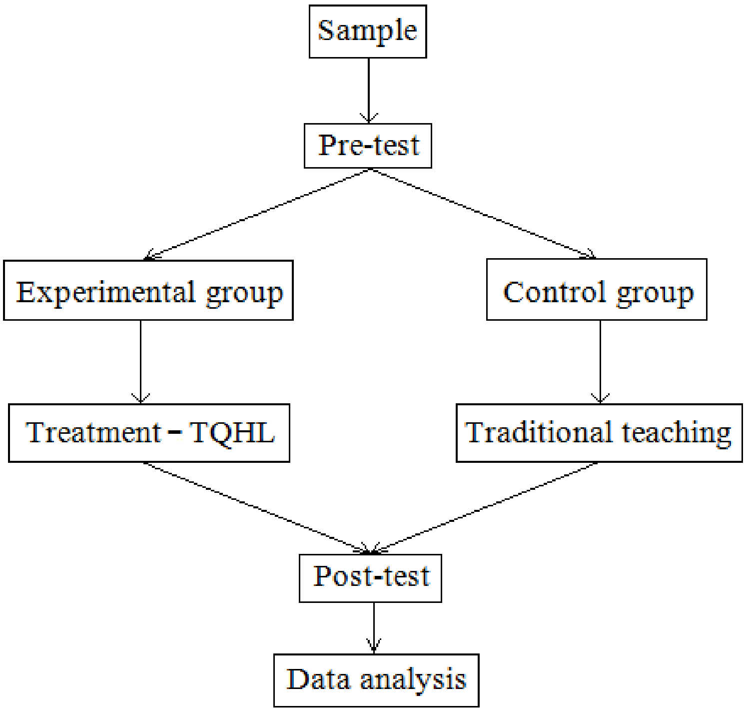

Figure 3.1: *Research design*

In this research the students in all five classes were pre-tested and groups E and C were created. The students in the group C were taught physics using the traditional teaching method, in terms of explicit teaching through lectures and teacher-led demonstrations planned according to the sixth-grade curriculum determined by the Ministry of Education, Science and Technological Development of the Republic of Serbia. The treatment in the form of teaching by using the TQHL charts in physics class was applied to the students in group E. The topics taught during the research were: (1) Mass and Density and (2) Pressure. Both topics are determined by the regular primary school curriculum. The same teaching units were taught to the students in both groups for the same time. These teaching units were: The law of inertia; Mass; Measurement of mass; Mass and weight as different concepts; Density; Determination of density; Determination of density of solid bodies of regular and irregular shape; Determination of density of liquid by measuring its mass and volume; The concept of pressure; Solid body pressure; Hydrostatic pressure and Atmospheric pressure. Afterwards, a physics knowledge test created by the researchers was administrated for post-testing. The selected teaching units were convenient for this research because within them, concepts from everyday life are treated. Accordingly, prior knowledge could be easily activated. Further, with the application of this strategy, some misconceptions that students formed through different life situations, before the formal education process, can be discovered.

In primary schools in the Republic of Serbia, the groups of students are pre-constituted (in the form of school classes) in order to meet the requirement of the obligatory school structure defined by the Ministry of Education, Science and Technological Development of the Republic of Serbia. Besides, the participants could not be randomly assigned to the groups, hence quasi-experimental research design was used. This is often the case in educational research and researchers have to choose a control group that is equivalent to the experimental group (Muijs, 2004; as cited in Tok, 2013). Five school classes were pre-tested to enable choosing the suitable groups E and C. Two school classes formed group E and another two school classes formed group C. One of the variables that were used to evaluate the similarity is overall success at the end of the fifth grade. If the average mark for all subjects at the end of the fifth grade was above 4.5, the student was categorized as excellent; the students with the average mark between 3.5 and 4.5 were very good; and the students with average mark between 2.5 and 3.5 were good. Nobody had average mark lower than 2.5. In this research, the overall success of each student was expressed as whole numbers, without decimal places (Excellent = 5, Very good = 4, Good = 3). An independent samples t-test showed that there was no significant difference in the overall success at the end of the fifth grade of the students in group E ($M = 4.5536$, $SD = .65836$) and the group C ($M = 4.5370$, $SD = .60541$); $t(108) = .137$, $p = .891$. Additionally, a physics knowledge test created by researchers was administrated for pre-testing. Students' metacognition was evaluated with a questionnaire on metacognition. Two physics knowledge tests (pre-test and post-test) were constructed for the purpose of this research. Reliability and validity of both tests, as well as for questionnaire on metacognition, will be discussed. An independent samples t-test showed that there was no significant difference in the PKTi scores of the students in group E ($M = 9.95$, $SD = 4.52$) and group C ($M = 10.67$, $SD = 4.57$); $t(108) = -.831$, $p = .408$. Besides, there was no significant difference in QMi scores of the students in group E ($M = 71.57$, $SD = 8.653$) and group C ($M = 72.04$, $SD = 8.068$); $t(108) = .292$, $p = .771$.

During the performance of a pedagogical experiment in a selected school, one teacher taught physics to all sixth grade classes. That teacher was teaching both groups (E and C) while the lessons were prepared by the teacher and the research team together. A Ph.D. student in

Teaching Sciences (physics) and a university professor in the field of Teaching Sciences (physics) constituted the research team. The lessons were realized by the teacher during the regular class hours. Since the teacher had to be trained to use the TQHL charts in class he had to be informed about research. During the two weeks the research team held meetings with the teacher. The researchers introduced the TQHL charts to the teacher and stated many different examples for application of charts in teaching. Besides, the importance of filling in certain columns is highlighted and adequate explanation is given. The teacher was probably able to anticipate proposed hypothesis, but regardless this fact, the expected results were not specified to him/her. Researchers have no reason to think that the teacher influenced on the results of the research in any other way than using suggested teaching interventions. During the research, researchers were constantly in the contact with the teacher and were assisting if needed and the teacher regularly reported to the research team about the experimental classes (researchers did not attend classes).

When introducing the mKWL strategy to the students, the teacher wrote in the TQHL chart (Figure 3.2) on the blackboard and each student wrote the same chart for him-/herself at his/her desk.

<table>
<tr><td colspan="4">Topic:
____
Before you begin learning, list details in the first column. After completing it, fill in the last column.</td></tr>
<tr><td>What I Think and what I know</td><td>What Questions I have</td><td>How can I find out</td><td>What I Learned</td></tr>
</table>

Figure 3.2: *The TQHL chart*

The teacher additionally explained to the students that they should write in the T column (Figure 3.2) not only those things they know undoubtedly, but their opinion and ideas as well. This column is particularly useful for students from Serbia because they are rarely connecting teaching content with their prior knowledge (although students have experiential knowledge or knowledge about the same content taught within other school subjects) (Milošević & Luković, 2006). Nevertheless, they usually have fear to make a mistake when they need to express their opinion. Furthermore, this column gave the teacher the information about students' potential misconceptions about the assigned teaching unit.

The teacher and the students filled in the Q column (Figure 3.2) by writing down all the questions the students thought about. In the H column they listed students’ proposals of how they can get the answers to these questions. The most common students’ proposals for inquiry were searching internet, reading textbooks, conducting experiments etc. In order to fill the L column (Figure 3.2) students had to summarize and recall what they learned. For two more weeks the students worked in the groups and the teacher was helping them with their TQHL charts. The teacher reminded students about chart columns when needed. Afterwards, each student was prepared to write the TQHL charts individually. When students became trained for this strategy, some teaching units were realized using the TQHL charts while students worked in the groups (or even as a whole class activity) and others were realized using the TQHL charts while students worked individually. Moreover, students started using the TQHL charts for homework and even for independent learning of the given teaching units. During the classes the teacher helped students only by providing them the opportunity to implement inquiry they have chosen. If the students were working individually during one physics class (or for homework), the next class was dedicated for the analysis of the same teaching unit. Each student analyzed his/her chart and then the whole class was included in the discussion about different questions, inquiries and conclusions that students had. Afterwards, each student had to insert into the L column some new information that he/she had adopted.

The problem that the teacher has encountered while using the TQHL charts was the lack of time for the realization of the teaching unit within a school hour. Besides, the teacher stated that much more time is needed to prepare lessons when this strategy is being used. The teacher must anticipate all possible ideas for students’ inquiry and prepare materials for experiments that students might propose, and also provide different study materials and internet access (whereas most schools in the Republic of Serbia do not have internet access).

It was noticed that, when first introducing TQHL charts, the students in group E were writing only definitions, physical laws and facts they undoubtedly knew, most commonly learned in previous physics lessons. As the time passed, they began more freely to fill in the first column of the chart. Two charts filled in by one student will be given as an example (Figure 3.3, Figure 3.4). Example of TQHL chart for the teaching unit “Mass and weight as different concepts” is shown in Figure 3.3. That was the teaching unit treated on the 4th physics class from the beginning of performing pedagogical experiment. The 20th teaching unit during the pedagogical experiment was “Atmospheric pressure”. Example of TQHL chart for this teaching unit is given in Figure 3.4.

The students taught by the use of mKWL strategy were mostly suggesting that the answers could be found out on the Internet. This can be attributed to the fact that students have easy access to information on the Internet and that the use of computers and Internet browsing has entered the everyday life of students. After the completion of the research, the teacher stated that even with a lot of effort, he has failed to significantly alter this fact.

<table>
<tr><td colspan="4">Topic:
<u>Mass and weight as different concepts</u>
Before you begin learning, list details in the first column. After completing it, fill in the last column.</td></tr>
<tr><td>What I Think and what I know</td><td>What Questions I have</td><td>How can I find out</td><td>What I Learned</td></tr>
<tr><td>– All objects have mass; it is a measure of the amount of matter in the object.
– I have about 35kg.
– The mass is a numerical measure of inertia.
– It is hard to move massive object.</td><td>– Why do all objects have mass?</td><td>– Look up on the Internet.</td><td>– The weight of an object is defined as the force of gravity on the object.
– Mass unit is kg and weight unit is N
– Mass of an object is the same on Moon and Earth, and weight is different.</td></tr>
</table>

Figure 3.3: *Example of the TQHL chart for the teaching unit "Mass and weight as different concepts"*

Topic: <u>Atmospheric pressure</u> Before you begin learning, list details in the first column. After completing it, fill in the last column.			
*What I **T**hink and what I know*	*What **Q**uestions I have*	***H**ow can I find out*	*What I **L**earned*
– It has something to do with weather forecast. – It is expressed in millibars. – The air is everywhere around us. – The air has its weight. – I suppose that atmospheric pressure is pressure exerted by air. – Atmospheric pressure is not the same somewhere on the mountain and on the sea level.	– What is correlation between atmospheric pressure and weather? – Why the atmospheric pressure is not the same somewhere on the mountain and on the sea level?	– Look up on the Internet.	– Atmospheric pressure is measured by barometer and it can be expressed in millimeters of mercury as well as in other units. – Usually, if the atmospheric pressure is high it will be warm and sunny, and if the atmospheric pressure is low, the weather will be bad. – Atmospheric pressure is not the same somewhere on the mountain and on the sea level because it is not the same height of the air column that exerts pressure by its weight in these two cases.

Figure 3.4: *Example of the TQHL chart for the teaching unit "Atmospheric pressure"*

3.6. Research Instruments

3.6.1. Physics Knowledge Test

Two physics knowledge tests (pre-test and post-test) were constructed for the purpose of this research. Both tests consist of 12 items in the form of multiple-choice tasks. Due to different cognitive demand of the tasks, not all tasks were equally scored: 6 tasks were scored with 1 point each, 4 tasks were scored with 2 points each and 2 tasks were scored with 3 points each. The researchers have estimated reliability and validity of both tests.

The obtained Cronbach's alpha coefficients for the pre-test and the post-test are .74 and .68, respectively. According to Murphy and Davidshofer (1988) Cronbach's alpha coefficient is, even low, acceptable above .60. Moreover, Nunnally (1967) stated that self-developed scales are acceptable with Cronbach's alpha coefficient of .60. Although the obtained values for Cronbach's alpha coefficient are relatively low for both tests, they indicate that the tests have acceptable reliability. Since both physics knowledge tests constructed for this research consists of 12 items and Cronbach's alpha coefficient strongly depends on the number of items, and since in the pilot study these coefficients were over .75 for both tests (.75 for the pre-test and .72 for the post-test), the researchers retained those 12 chosen items in the tests.

Based on the students' understanding of the test items in the pilot study, some minor revisions were made in the formulations of the test items. Further, as proposed by Segedinac, Segedinac, Konjović and Savić (2011; as cited in Hrin, Fahmy, Segedinac & Milenković, 2015), the expert team was formed in order to estimate the validity of the applied tests. Two primary school physics teachers, a school pedagogue (school pedagogue, among other things, assists teachers with pedagogy and advices about teaching) and a university professor in the field of Teaching Sciences (physics) constituted the expert team. According to this expert team, the test items were appropriate for sixth-grade students, formulations were precise and easy to understand. Moreover, the tests complied both with the school curriculum and the available physics books approved by the Ministry of Education, Science and Technological Development of the Republic of Serbia. Hence the formed expert team confirmed that the tests were valid.

The time assigned for the pre-test and the post-test was the same – one class hour (45 minutes). The following are the examples of the test items.

1. *The test item in the level of knowledge:*

The SI unit for pressure is:

a) Kilogram (kg)

b) Newton (N)

(c) Pascal (Pa)

2. *The test item in the level of comprehension:*

If two bodies have equal masses, and the contact surface of the first body and the floor is greater than the contact surface of the second body and the floor:

a) The pressure exerted by the first body is greater than the pressure exerted by the second body

(b) The pressure exerted by the second body is greater than the pressure exerted by the first body

c) We cannot know which body exerts greater pressure

3. *The test item in the level of application:*

A table on four legs has weight of 40 N. Each leg sets against the floor with the area of 0.001 m^2. What pressure does the table exert on the floor?

a) 400 Pa

b) 1000 Pa

(c) 10 000 Pa

d) 40 000 Pa

The used physics knowledge tests are given in Appendixes (7.1. Pre-test, and 7.2. Post-test). Moreover, it is stated which test items are used for evaluating different cognitive levels (7.3. Test Items Classified Using Bloom's Taxonomy of Educational Objectives).

3.6.2. A Questionnaire on Metacognition

A questionnaire on metacognition was used for evaluation of metacognition within both, pre-test and post-test. For this purpose, the Junior Metacognitive Awareness Inventory (Jr. MAI), developed for children under the age of 14 by Sperling, Howard, Miller and Murphy (2002), was adapted. The Metacognitive Awareness Inventory (MAI) was first proposed in the early nineties by Schraw and Dennison (1994). MAI questionnaire is intended to assess metacognitive skills of adolescents and adults and contains items that examine each of the eight components: knowledge of cognitive processes (declarative, procedural and conditional) and regulation of cognitive processes (planning, information management, monitoring, evaluation and debugging in thinking process). Listed metacognitive components, except for debugging in thinking process, are estimated with Jr MAI. The questionnaire on metacognition used in this research consisted of 18 items, appropriate for the selected sample (the choice of items was tested in a pilot study). Students were asked to respond to the statements using a five-point Likert Scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree). The data obtained using Jr. MAI were tested for internal consistency, calculating the Cronbach's alpha coefficient. The obtained value for Cronbach's alpha coefficient was .70 which, according to George and Mallery (2003), indicated that the scale of the instrument satisfied the requirement for reliability. The questionnaire was administered during the first class of conducting experiment, when the teacher informed the students about research. The PKT (pre- test) was administered during next school hour. The time assigned for the questionnaire was approximately 15 minutes.

Examples of items in Jr. MAI:

- I know when I understand something.
- I try to use the ways of studying that have worked for me before.
- I learn best when I already know something about the topic.
- I learn more when I am interested in the topic.
- I think of several ways to solve a problem and then choose the best one.
- I draw pictures or diagrams to help me understand while learning.

Components of metacognition which are evaluated with particular items are listed in the table given in Appendixes (7.4. Metacognitive Components Evaluated Using Jr. MAI).

3.7. Statistical Analysis of Data

The obtained data were treated statistically using the software package IBM SPSS Statistics 20 and Microsoft Office Excel. Scores in the physics knowledge tests (PKTi and PKTf) are analyzed within this research, as well as scores on the questionnaire on metacognition (QMi and QMf). These variables were described using descriptive statistics (Mean, Median, Mode, Std. Deviation, Coefficient of variation, Minimum, Maximum, Range, Standardized Skewness and Standardized Kurtosis). Since all the variables, PKTi, PKTf, QMi and QMf, satisfied the requirements of normal distribution (confirmed by Shapiro-Wilk test of normality and by obtained values of standardized skewness and standardized kurtosis), a paired samples t-test was used in order to compare students' performance and metacognition on the pre-test and post-test for group E, as well as for group C. In order to compare the post-test scores (both, PKTf and QMf) between the students in groups E and C, an independent samples t-test was performed. Additionally, percentage of the correct answers on the PKTi and the PKTf items in both groups is shown in the form of histogram. An independent-samples t-test was performed to compare students' performance and metacognition between the male and female students in both, group E and group C. A paired-samples t-test was performed to compare the PKTf and PKTi, as well as the QMf and the QMi scores of male and female students in both groups. In order to analyze relationship between students' performance in physics and metacognition, Pearson correlation is calculated for PKTi and QMi, as well as for PKTf and QMf (for all students unified and, separately, for the students in group C and the students in group E) and linear regression is carried out.

4. Research Results and Discussion

4.1. The Impact of the Modified Know-Want-Learn Strategy and Gender on Students' Performance

4.1.1. The Impact of the Modified Know-Want-Learn Strategy on Students' Performance

Students' test scores, both PKTi and PKTf, could range from 0 to 20 points. A higher score in the test denoted greater performance in physics. The data are assumed to be normally distributed. Normality was tested using Shapiro-Wilk normality test. There is no deviation from normality within the groups according to the Shapiro-Wilk test. For the students in group C, the PKTi score probability of the observed value, $W = .968$, is: $p = .157$; and for the PKTi score of the students in group E: $W = .960$, $p = .059$. For the PKTf score of the students in group C, values are: $W = .972$, $p = .240$; and for PKTf score of the students in group E: $W = .944$, $p = .110$. Additionally, standardized skewness and kurtosis were used to evaluate deviation from normality. These values (Table 4.1) are suggesting that the data are normally distributed.

The students in group E increased their test scores (from the PKTi to the PKTf) by 4.12 points on average, as indicated in Table 4.1. Since PKTi and PKTf scores satisfied the requirements of normal distribution, a paired-samples t-test was performed to compare the PKTf and the PKTi scores. There was a significant difference in the PKTf ($M = 14.07$, $SD = 4.20$) and the PKTi ($M = 9.95$, $SD = 4.52$) scores for the students in group E; $t(55) = -5.20$, $p < .0001$.

However, there was no significant difference between the PKTf ($M = 11.17$, $SD = 4.49$) and the PKTi ($M = 10.67$, $SD = 4.57$) scores for the students in group C; $t(53) = -1.88$, $p = .065$.

Table 4.1. *Basic descriptive statistics related to PKT scores*

	Group C		Group E	
	PKTi	PKTf	PKTi	PKTf
N	54	54	56	56
Mean	10.67	11.17	9.95	14.07
Median	11.00	11.00	10.00	14.00
Mode	9[a]	11[a]	11	13[a]
Std. Deviation	4.572	4.488	4.518	4.203
Coefficient of variation	0.428	0.388	0.454	0.286
Minimum	3	3	3	5
Maximum	20	20	19	20
Range	17	17	16	15
Standardized Skewness	0.385	-.142	0.843	-1.451
Standardized Kurtosis	-1.266	-1.110	-1.287	-0.898

a. Multiple modes exist. The smallest value is shown

An independent-samples t-test was performed to compare the PKTf scores between the students in group E and group C. There was a significant difference in the PKTf scores of the students in group E ($M = 14.07$, $SD = 4.20$) and group C ($M = 11.17$, $SD = 4.49$), in favor of the students in group E; $t(108) = -3.505$, $p = .001$.

According to these results it can be suggested that the use of the mKWL strategy increases students’ performance in physics, if performance refers to teacher's assessment of students’ achieving learning objectives based on test results and therefore is reflected in students’ marks in physics.

Additionally, there is an evident difference between histograms that show percentage of the correctly answered test items in group E and group C on the PKTi (Figure 4.1) and on the PKTf (Figure 4.2).

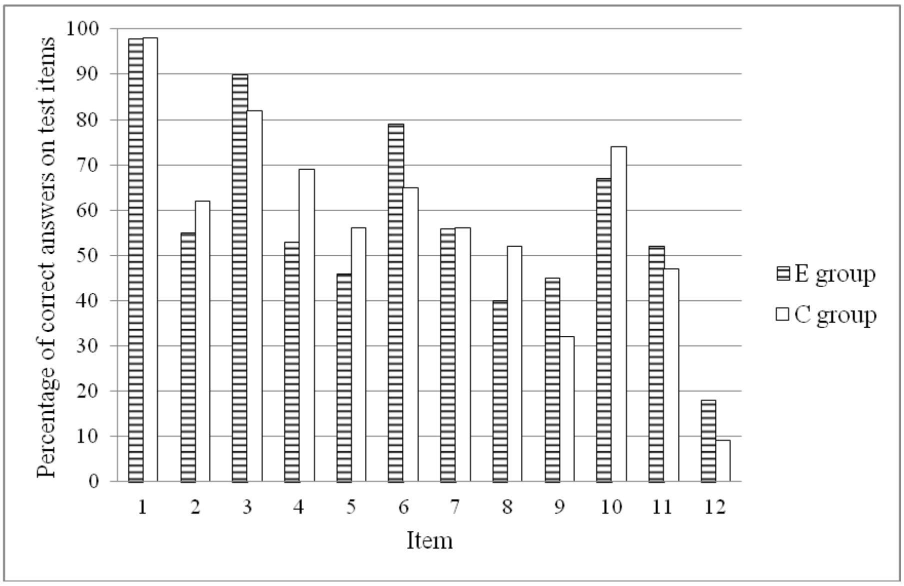

Figure 4.1: *Comparison of percentage of the correctly answered test items in group E and group C on the PKTi*

There is no apparent difference in percentage of the correctly answered test items in group E and group C on the PKTi. For some items more successful were the students in group E and for other items more successful were the students in group C.

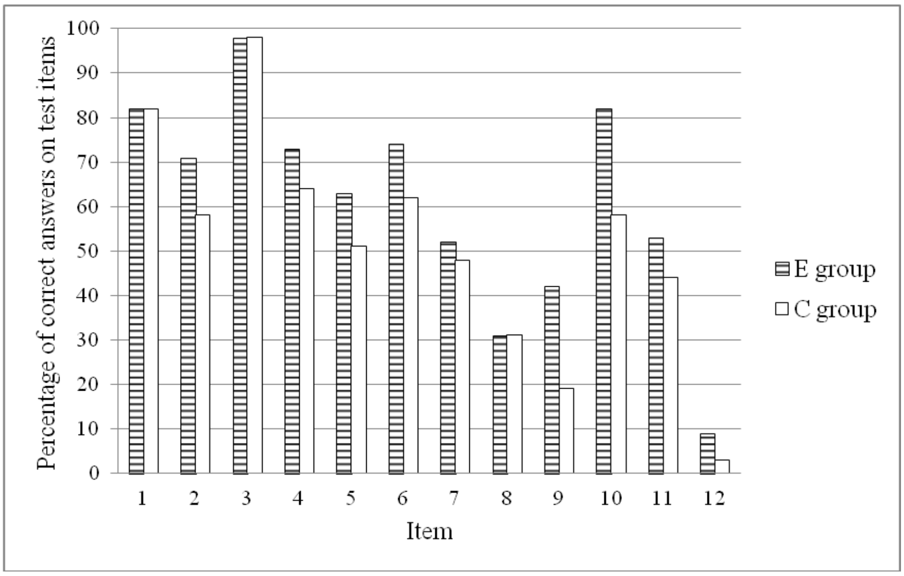

Figure 4.2: *Comparison of percentage of the correctly answered test items in group E and group C on the PKTf*

Figure 4.2 shows comparison of percentage of correct answers on the PKTf items in groups E and C. There were only three questions that students of both groups have answered equally well. Two of those were the questions in the domain of knowledge that required recalling facts. In higher levels of knowledge, it is shown that the students in the experimental group were more successful.

The PKTi and PKTf scores for each student in group C are shown in the Figure 4.3, where it can be seen that the post-test and pre-test scores were relatively the same. There were 25 students that achieved higher scores in pre-test. It means that students' performance in physics remained unchanged on average, as it is stated based on the results of performed t-test.

The PKTi and PKTf scores of the students in group E can be seen in the Figure 4.4, where it is showed that the post-test score was higher than the pre-test score for most students. Only 13 students achieved higher scores in pre-test. It means that using mKWL strategy increased the students' performance on the selected topics in physics.

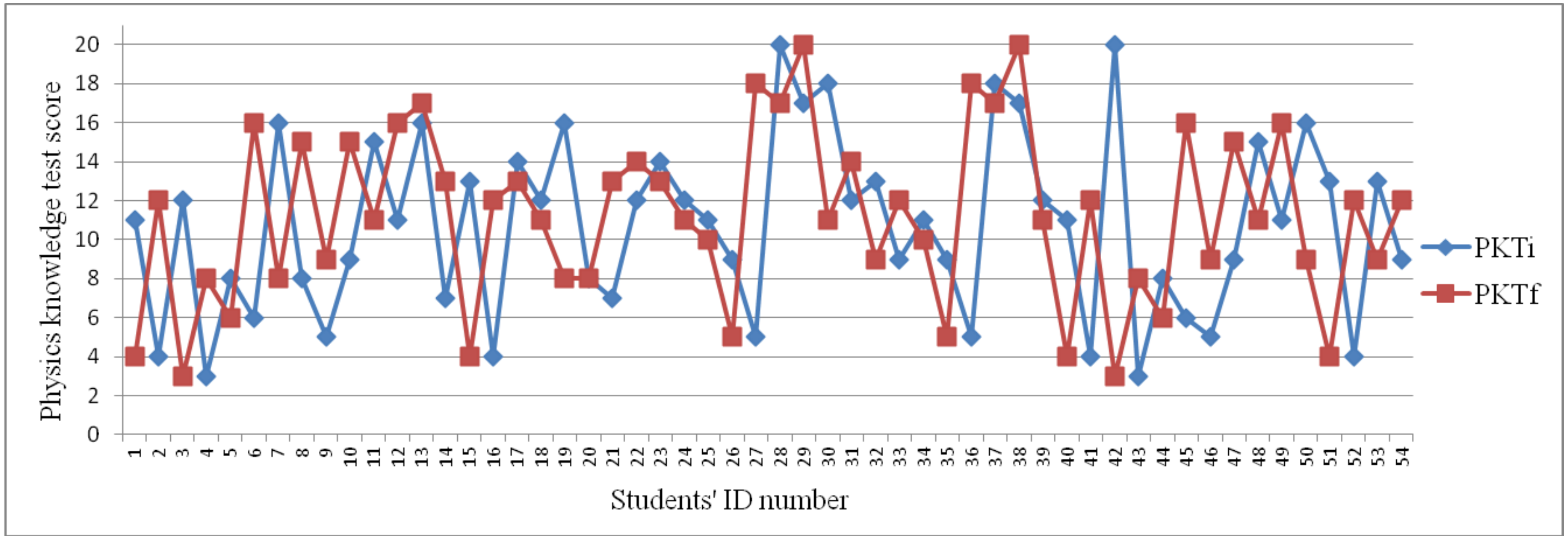

Figure 4.3: *Graph for PKTi and PKTf scores of group C*

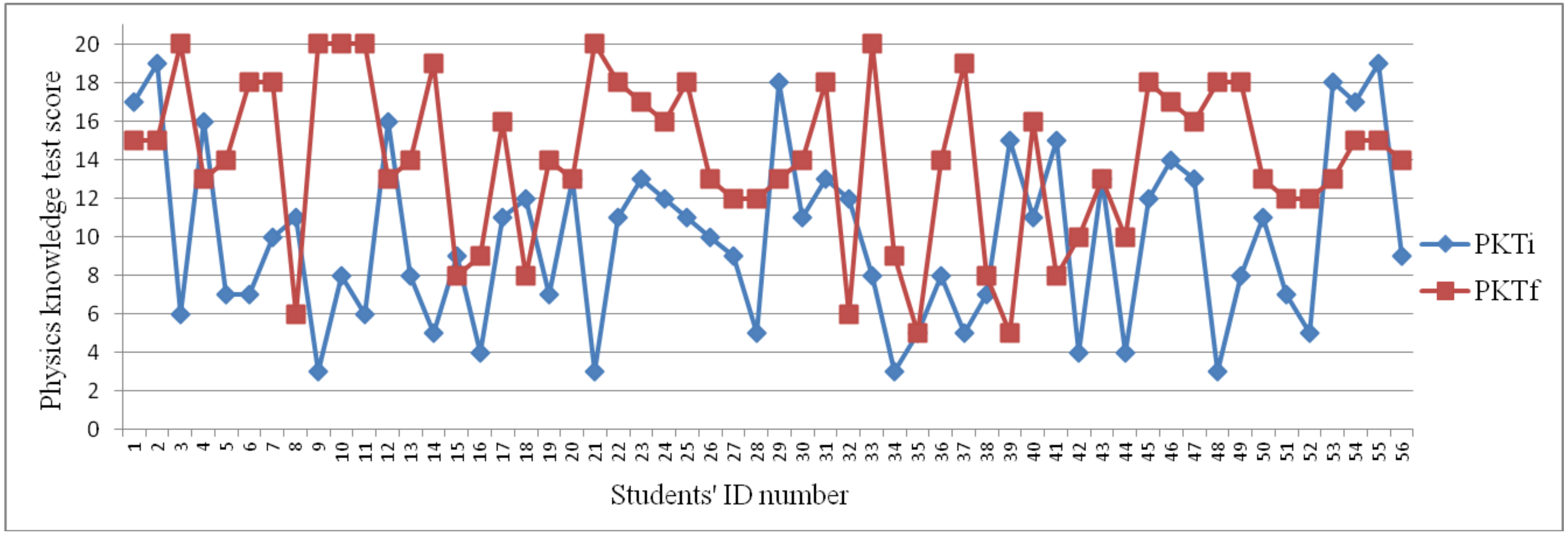

Figure 4.4: *Graph for PKTi and PKTf scores of group E*

Numerous studies are carried out to examine how enriching and improving teaching strategies can help in teaching physics, and science in general (Cvjeticanin, Obadovic & Rancic, 2015; Ilić, Đurić & Stanisavljević, 2015; Milenković, Segedinac & Hrin, 2014; Popović, Miljanović, Županec & Pribićević, 2014; Sağlam, 2010). The effect of the mKWL strategy on sixth-grade students' performance in physics is examined in this research.

It is shown that two groups of students (E and C) had similar prior knowledge regarding some physics topics. That was expected since the students in both groups were taught by the same physics teacher in the same manner (before this research).

Based on Table 4.1, it can be observed that the mean post-test score in the physics knowledge test of the group of students taught using the TQHL charts is 20.6% higher than their mean pre-test score in the physics knowledge test. That difference reflects in a higher average mark of the students in group E. It was expected that students will achieve better results in physics after using the TQHL strategy, because different studies indicated that this strategy enables students to activate their prior knowledge, choose the problem they are interested in and choose the method of inquiry. Students easier realize connection between prior knowledge and new knowledge. Since the students' interests are considered, students' motivation is enhanced. However, it is questionable whether the post-test scores were better only for the fact that the use of the TQHL charts was new and therefore interesting to students. It cannot be stated whether continuous use of this strategy would result in even better scores (since the students would be better trained to use the strategy) or in poorer ones (if students lose interest for using the strategy).

As the students taught using direct teaching were taught in the way they were used to, it was expected that there would not be significant difference between the pre-test and the post-test scores.

The results revealed that the post-test scores of students taught using the TQHL charts were 14.5% higher than the post-test scores of students taught using direct teaching (Table 4.1). This was precisely the result that was expected together with the first one. It can be suggested that this better performance is the result of the use of the TQHL charts.

Based on Figure 4.2, it can be observed that after the implementation of this strategy, the students achieved better results at all levels of knowledge. The use of the TQHL charts can help students acquire functional knowledge. Students use prior knowledge to design and implement inquiry, thus students practice the application of knowledge. In case of using the TQHL charts one finds that high levels of student engagement results with higher levels of knowledge compared to the case where students are mainly trying to memorize facts during the use of direct teaching.

There are no other studies that examined the usage of the same mKWL strategy in physics learning, hence these findings can be compared only with findings of similar studies. The findings of this research are consistent with the findings of other researchers that have examined the efficiency of the KWL strategy or its modifications to enhance students' performance in various academic disciplines. The main difference between this research and the similar ones is that the use of the TQHL charts was particularly examined within this research, and it is proposed as an appropriate strategy for teaching physics.

The findings of this research are in line with the findings of various researchers who showed that the use of the KWL strategy increased students' performance in science (Akyüz 2004; Taslidere & Eryilmaz, 2012; Reichel, 1994; as cited in Tok, 2013). Akyüz (2004) examined students' performance regarding the topic Heat and Temperature when the KWL strategy was used, and suggested that the use of this strategy increased ninth-grade students' performance. Taslidere and Eryilmaz (2012) showed that integrating the KWL strategy and the conceptual physics approach improves students' performance in Optics. This research was carried out with ninth-grade students. According to Reichel (1994; as cited in Tok, 2013) students subjected to the KWL strategy perform better in science. Tok (2013) showed the positive effect of using the KWL strategy on the sixth-grade students' performance in mathematics, students' metacognition and mathematics anxiety. Davis (1993) suggested that proposing questions and giving answers promote content comprehension, which largely reflects on physics performance. It is shown that the KWL strategy is effective in increasing sixth-grade students' physics performance and their metacognition (Zouhor, Bogdanović & Segedinac, 2016).

Sumardiono (2014) showed that the application of the KWLH charts made students automatically sharpen their critical thinking such that they were able to filter what they need in comprehending and solving the physics tasks. This strategy encourages students to think about the possible ways of expanding their knowledge (Weaver, 1994) and it supports the organization of new information (Cavner, 2013). Therefore, the KWLH is an effective teaching strategy (Walker Tileston, 2004; Sumardiono, 2013). Modifications of the KWL strategy that can enhance students' performance in science are the KLEW(S) (Hershberger et al., 2006; Hershberger & Zembal-Saul, 2015) and KNWS (Sumardiono, 2014). According to Crowther and Cannon (2004) the use of the THC strategy in primary school improves learning sciences and literacy.

The implication of the results of this research is that sixth-grade students' performance in physics is higher when students are taught using the TQHL charts rather than direct teaching, or in other words, better marks in physics are expected when using the proposed strategy. Based on that, it can be suggested that using the mKWL strategy in teaching physics has a positive effect on students' performance.

4.1.2. Gender Differences in Students' Performance

Shapiro-Wilk test of normality and standardized skewness and kurtosis are suggesting that there is no deviation from normality within the groups of data in connection with physics knowledge tests (Table 4.2). The only group of data with p-value less than .05 ($p = .028$) is PKTf for the male students in group E. However, since the value of standardized skewness is (-1.53947) and of kurtosis is (-0.26719) i.e. in the range -2 and 2, it is assumed that the data for this group also have normal distribution. An independent-samples t-test was performed to compare the PKTi / PKTf scores between the male and female students in group E, as well as in group C; a paired-samples t-test was performed to compare the PKTf and the PKTi scores of male / female students in both groups.

Table 4.2: *Shapiro-Wilk Test of normality and values of standardized skewness and kurtosis for the groups of data about PKT scores*

Test	Gender	Shapiro-Wilk			Standardized Skewness	Standardized Kurtosis
		Statistic	df	Sig.		
PKTi – group C	male	.947	25	.215	-0.40302	-1.16962
	female	.953	29	.223	0.368664	-1.13964
PKTf – group C	male	.955	25	.323	-0.89871	-0.69069
	female	.959	29	.307	0.076037	-1.09467
PKTi – group E	male	.969	26	.603	0.714912	-0.47802
	female	.950	30	.172	0.5363	-1.20288
PKTf – group E	male	.911	26	.028	-1.53947	-0.26719
	female	.960	30	.304	-0.85012	-0.65306

An independent-samples t-test showed that there was no significant difference between the PKTi scores between the male (M = 10.16, SD = 4.007) and female (M = 11.10, SD = 5.038) students in group C; t (52) = -.753, p = .455; and there was no significant difference between the PKTf scores between the male (M = 10.80, SD = 3.937) and female (M = 11.48, SD = 4.961) students in group C; t (52) = -.554, p = .576.

It is shown that there was no significant difference between the PKTi scores between the male (M = 9.81, SD = 4.280) and female (M = 10.07, SD = 4.785) students in group E; t(54)= -.212, p=.833. The same for PKTf scores between the male (M = 15.19, SD = 4.079) and female (M = 13.10, SD = 4.130) students in group E, there was no significant difference; t (54) = 1.901, p =.063.

A paired-samples t-test has shown that for the male students in group C there was no significant difference between the PKTi (M = 10.16, SD = 4.007) and PKTf (M = 10.80, SD = 3.937) scores; t (24) = -.551, p = .587; and for the female students in group C there was no significant difference between the PKTi (M = 11.10, SD = 5.038) and PKTf (M = 11.48, SD = 4.961) scores; t (28) = -.310, p = .759.

For the students in group E, both male and female, there was significant difference between the PKTi and PKTf scores. Male students achieved better results on the PKTf (M = 15.19, SD

= 4.079) than on the PKTi (M = 9.81, SD = 4.280); t (25) = -4.059, p = .000; and female students also achieved better results on the PKTf (M = 13.10, SD = 4.130) than on the PKTi (M = 10.07, SD = 4.785); t (29) = -2.744, p = .010.

Schematic representation of stated results is given in Figure 4.5.

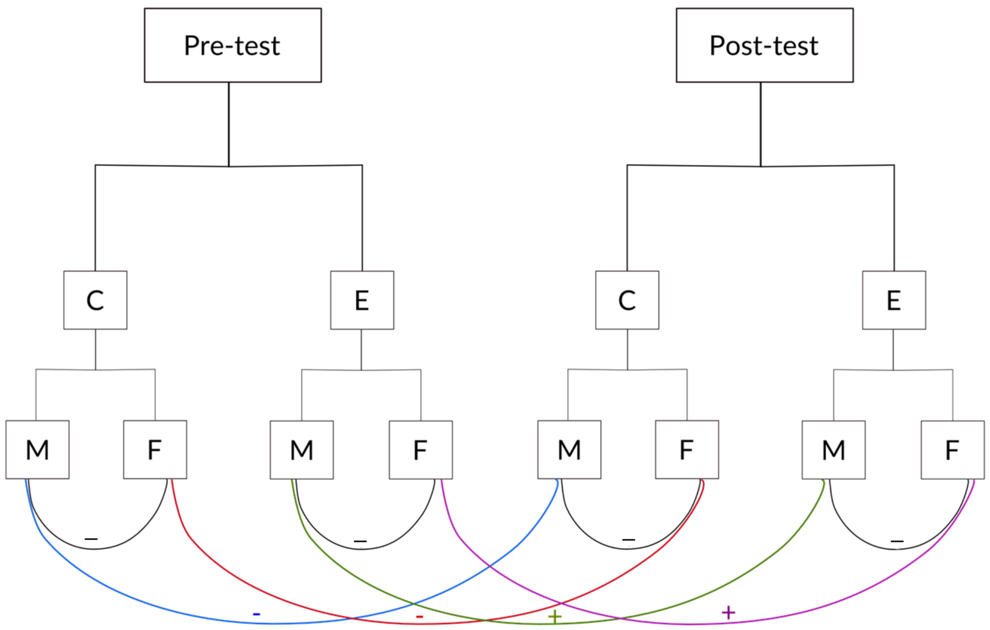

Figure 4.5: *Schematic representation of differences in students' performance (+ meaning the difference is statistically significant; - meaning the difference is not statistically significant)*

Regarding gender differences in students' performance, it is shown that, in this research both male and female students have achieved similar results. There was no significant difference between the scores of the male and female students in group E, and the same in group C. This finding is in accordance with some studies, whereas the other showed different results. Various studies have shown different results regarding gender differences. Some studies about students' performance in relation to gender concluded that boys perform better in mathematics and science while girls perform better in language and arts (Hedges & Nowell, 1995). In the literature about students' performance in science, number of authors reported findings in favor of boys (Bacharach, Baumeister, & Furr, 2003; Evans, Schweingruber, & Stevenson, 2002; Keeves, 1992; Nosek et al., 2009), however some researchers report that there is no difference in students' performance related to gender (Cole, 1997; Goldin, Katz, & Kuziemko, 2006; Keeves, 1992; Sorge, 2007; Spelke, 2005).

Hsin-Hui (2015) stated that the gender gap in science performance is evident and it starts as early as in third grade. According to this author, male students have higher performance than female students. On the contrary, by comparing success of male and female students in period from fourth to eighth grade, Bursal (2013) has shown that female students have at least slightly higher science success than male students. That spotted difference became statistically significant as the grade level increased. Some researchers (Serin, 2010; Yaman & Dede, 2007) have obtained results that indicated difference in favor of female students.

According to Bloom (1976), and as confirmed by other researchers (Evans et al., 2002; Mattern & Schau, 2002), attitudes toward a subject area are one of the major indicators of a success in that subject area. According to that, Bursal (2013) have stated that present-day more positive attitudes toward science, can explain better science performance of girls.

The use of TQHL charts has contributed equally to male and female students' performance. This is important because when teaching in mixed-gender classrooms, the teacher should use strategies that suits female, as well as male students.

4.2. The Impact of the Modified Know-Want-Learn Strategy and Gender on Students' Metacognition

4.2.1. The Impact of the Modified Know-Want-Learn Strategy on Students' Metacognition

Students' scores in the questionnaire, both QMi and QMf, could range from 18 to 90 points. A higher score in the questionnaire indicated a higher level of development of metacognition. Normality can be assumed for this data set. According to Shapiro-Wilk normality test and values of standardized skewness and kurtosis, it is suggested that there is no deviation from normality within the groups. For the QMi scores of the students in group C: $W = .970$, is: $p = .187$ and in group E: $W = .966$, $p = .119$. For QMf scores of the students in group C: W =

.980, p = .508; and in group E: W = .954, p = .031. Additionally, standardized skewness and kurtosis were used to evaluate deviation from normality. These values (Table 4.3) are suggesting that the data are normally distributed. Although for the QMf score of the students in group E, p-value is less than .05, based on the values of standardized skewness (0.821317) and kurtosis (-1.21975) for this group of data, it is assumed that the data are normal.

The students in group E increased their QM scores (from the QMi to the QMf) by 4.61 points on average, as indicated in Table 4.3. Since QMi and QMf scores satisfied the requirements of normal distribution, a paired-samples t-test was performed to compare the QMf and the QMi scores. There was a significant difference in the QMf (M = 76.18, SD = 6.478) and the QMi (M = 71.57, SD = 8.653) scores for the students in group E; t (55) = -4.658, p < .0001.

However, there was no significant difference between the QMf (M = 71.22, SD = 8.144) and the QMi (M = 72.04, SD = 8.068) scores for the students in group C; t (53) = 1.993, p = .051.

Table 4.3: *Basic descriptive statistics related to students' scores on QM*

	Control group		**Experimental group**	
	QMi	QMf	QMi	QMf
N	54	54	56	56
Mean	72.04	71.22	71.57	76.18
Median	73.00	72.00	73.00	75.50
Mode	66[a]	63[a]	73[a]	75
Std. Deviation	8.068	8.144	8.653	6.478
Coefficient of variation	0.111993	0.11435	0.120903	0.085035
Minimum	57	54	54	65
Maximum	87	88	87	88
Range	30	34	33	23
Standardized Skewness	-0.26769	-0.4	-0.76176	0.821317
Standardized Kurtosis	-0.93271	-0.46948	-0.93471	-1.21975

a. Multiple modes exist. The smallest value is shown

Similar as for students' performance, for students' metacognition it is shown that 31 students in group C achieved higher scores in QMi than in QMf, while only 15 students in group E achieved higher scores in QMi than in QMf (Figure 4.6).

An independent-samples t-test was performed to compare the QMf scores between the students in groups E and C. There was a significant difference in the QMf scores of the students in group E ($M = 76.18$, $SD = 6.478$) and group C ($M = 71.22$, $SD = 8.144$), in favor of the students in group E; $t(108) = -3.505$, $p = .001$.

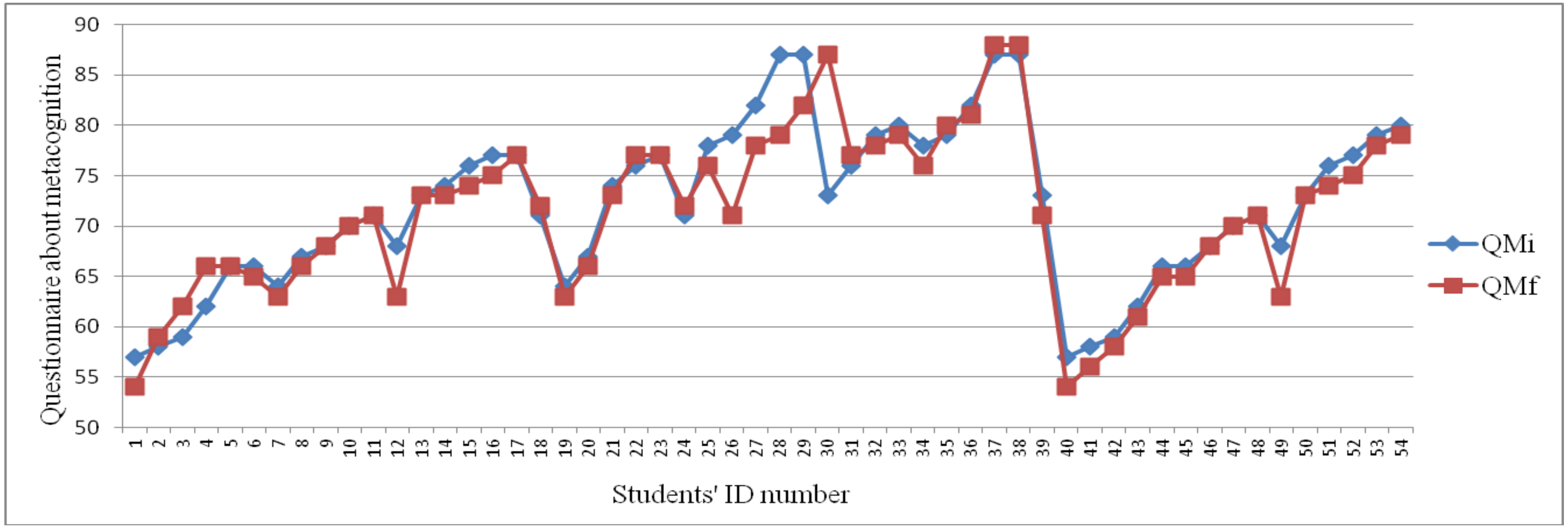

Figure 4.6: *Graph for QMi and QMf scores of group C*

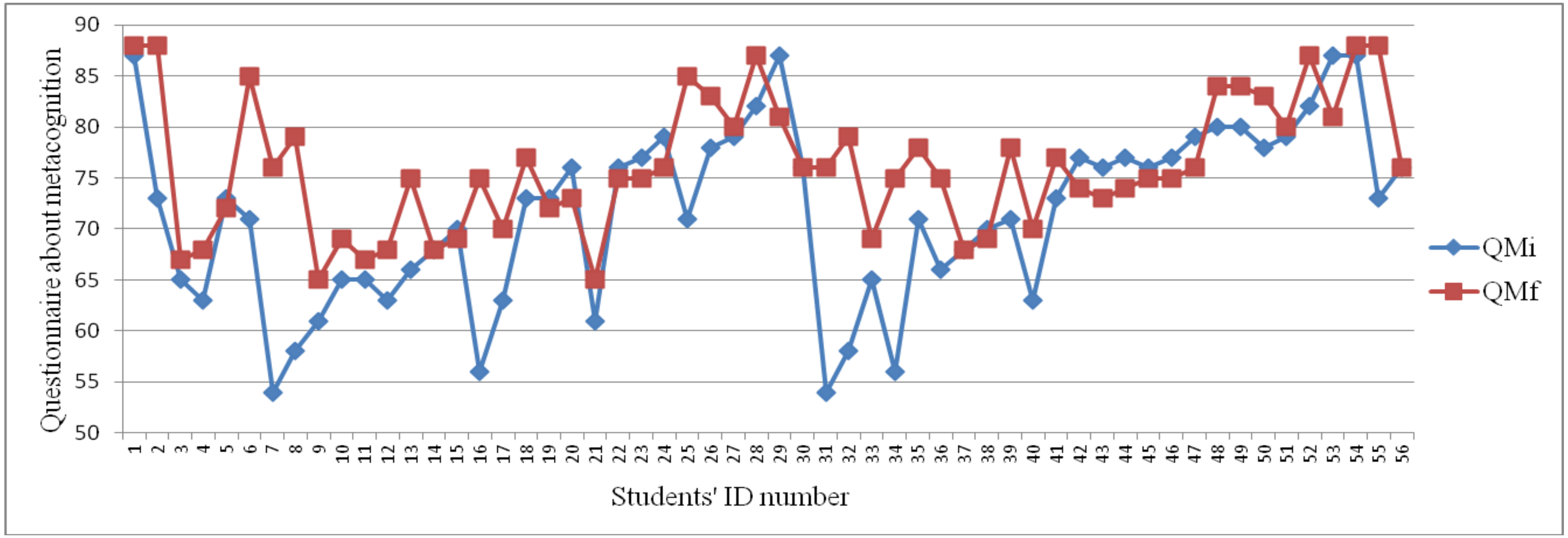

Figure 4.7: *Graph for QMi and QMf scores of group E*

These results imply that the use of the mKWL strategy increases students' metacognition.

The findings of this research are in line with findings of other researchers about the effects of metacognitive strategies, including the KWL strategy, on students' metacognition (Kumari & Jinto, 2014; Mok et al., 2006; Ngozi, 2009; Ozsoy & Ataman, 2009; Tok, 2013). Mok et al. (2006) showed that the KWL strategy also had a positive effect as a tool for self-assessment and that it was efficient for promoting metacognition. Ngozi (2009) showed that students in the higher grades of secondary school who had practiced metacognitive strategies achieved better results within the sciences. Also, it was shown that the fifth-grade students in the group where a strategy for fostering metacognitive abilities had been applied significantly improved their metacognitive abilities and the skills of solving mathematical problems (Ozsoy & Ataman, 2009). The KWL strategy makes students be more engaged in the text and practice metacognition while reading. While writing the KWL chart, students must use metacognitive regulation, i.e. planning, information management, monitoring and evaluation. In that way, students' metacognition is promoted throughout the learning process (Mok et al. 2006). It is shown that KWL strategy can enhance the academic performance and metacognition of high school students, as well (Kumari & Jinto, 2014).

In this research it is shown that the group of students taught using the TQHL charts has achieved 6,4 % higher mean score on QMf than on QMi.

4.2.2. Gender Differences in Students' Metacognition

According to Shapiro-Wilk test and the analyzing values of standardized skewness and kurtosis it can be suggested that there is no deviation from normality within the groups of data in connection with the questionnaire on metacognition (Table 4.4). The only group of data with p-value less than .05 ($p = .041$) is QMf for the male students in group E. Nevertheless since the value of standardized skewness is (1.451754) and of kurtosis is (-0.56595) (in the range -2 to 2), it is assumed that the data are normally distributed. An independent-samples t-test was performed to compare the QMi / QMf score, between the male and female students in groups E and C; and a paired-samples t-test was performed to compare the QMf and the QMi scores of male / female students in both groups.

Table 4.4: *Shapiro-Wilk Test of Normality and values of standardized skewness and kurtosis for the groups of data about QM scores*

Questionnaire	Gender	Shapiro-Wilk			Standardized Skewness	Standardized Kurtosis
		Statistic	df	Sig.		
QMi – group C	male	.945	25	.197	-0.84052	-0.84479
	female	.945	29	.138	-1.01382	-0.6568
QMf – group C	male	.944	25	.182	-1.10345	-0.33038
	female	.959	29	.303	-1.01613	-0.43905
QMi – group E	male	.981	26	.885	0.359649	-0.2345
	female	.935	30	.067	-1.73536	0.234094
QMf – group E	male	.918	26	.041	1.451754	-0.56595
	female	.956	30	.242	0.526932	-0.68908

An independent-samples t-test showed that there was significant difference between the QMi scores between the male (M = 69.24, SD = 6.260) and female (M = 74.45, SD = 8.753) students in group C; t (52) = -2.477, p = .017, in favour of female students. Besides, it is showed that there was significant difference between the QMf scores between the male (M = 68.84, SD = 6.149) and female (M = 73.28, SD = 9.149) students in group C; t (52) = -2.056, p = .045, again in favour of female students.

It is shown that there was significant difference between the QMi scores between the male (M = 68.65, SD = 7.864) and female (M = 74.10, SD = 8.628) students in group E; t (54) = -2.454, p = .017. The same for QMf scores between the male (M = 74.23, SD = 6.936) and female (M = 77.87, SD = 5.637) students in group E there was significant difference; t (54) = -2.164, p = .035. For both, QMi and QMf scores, difference was in favour of female students.

A paired-samples t-test has shown that for the male students in group C there was no significant difference between the QMi (M = 69.24, SD = 6.260) and QMf (M = 68.84, SD = 6.149) scores; t (24) = 1.109, p = .278; and for the female students in group C there was no significant difference between the QMi (M = 74.45, SD = 8.753) and QMf (M = 73.28, SD = 9.149) scores; t (28) = 1.687, p = .103.

For the students in group E, both male and female, there was significant difference between the QMi and QMf scores. Male students achieved better results on the QMf ($M = 74.23$, $SD = 6.936$) than on the QMi ($M = 68.65$, $SD = 7.864$); $t(25) = -3.802$, $p = .001$; and female students also achieved better results on the QMf ($M = 77.87$, $SD = 5.637$) than on the QMi ($M = 74.10$, $SD = 8.628$); $t(29) = -2.804$, $p = .009$.

Schematic representation of stated results is given in Figure 4.8.

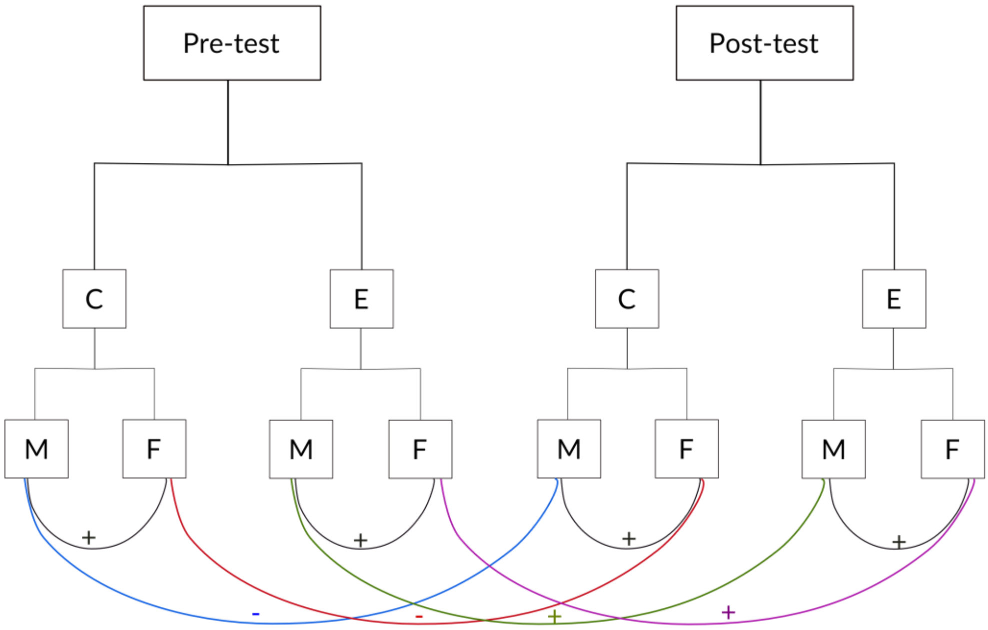

Figure 4.8: *Schematic representation of differences in students' metacognition (+ meaning the difference is statistically significant; - meaning the difference is not statistically significant)*

Regarding the students' metacognition in relation to gender, the obtained result is expected because it is in line with findings of a large number of previous studies that pointed to similar differences in metacognitive functioning between boys and girls. Various authors have suggested that the metacognition is higher for female students than for male students of the same age (Carr & Jessup, 1997; Singh, 2012). Research conducted in the Republic of Serbia, showed that girls in first grade of grammar school (15 years old) have higher level of metacognitive awareness than boys (Bogdanović et al., 2015). Fatin (2005) carried out research in Malaysia which showed that there is a statistically significant difference in the metacognitive abilities of the secondary school students and in their ability to solve calculative tasks in relation to gender, in favor of female students.

In the opinion of some authors, the differences between boys and girls in terms of metacognitive abilities appear predominantly in metacognitive knowledge components. In accordance with this, eighth-grade female students in Romania, have shown better results in these components than male students (Ciascai & Haiduc, 2011). Others indicate that girls are using self-monitoring more often in comparison to boys (Bidjerano, 2005). An analysis of the metacognitive abilities of undergraduate students in China suggests that there is a statistically significant difference, where female students show a higher level of self-regulation and a more positive attitude towards learning than male students of the same age (Downing, Chan, Downing, Kwong, & Lam, 2008).

However, among the previous studies, there are also results that are not in accordance with the above. Some authors state that differences in metacognitive abilities in relation to gender, which they apply in the field of mathematics, are not statistically significant (Zimermann & Martinez-Pons, 1990; Zhu, 2007), or that boys are at a higher level regarding the implementation of appropriate learning strategies (Niemivirta, 1997). Topçu and Yilmaz-Tüzün (2009) stated that the research carried out with the aim of investigating the gender differences related to metacognition, did not show a difference in the development of metacognitive abilities in relation to students' gender.

The inconsistency of the findings gained in previous studies can be justified by the fact that different studies have been carried out with different students' age. The age of respondents could be decisive for confirming or denying the difference in metacognitive abilities in relation to gender. In a research conducted in Swiss high schools, the expected gender-specific differences in the favor of female students were indicated. However, it has been established that the level of development of the strategies of monitoring and evaluation tends to equalize between genders during high school, while differences in planning remain constant (Leutwyler, 2009). The results of the research conducted in Turkey show that there is no significant difference in the teachers' metacognitive regulation in relation to gender, except in planning where difference exists in favor of female teachers (Çaliskan & Selçuk, 2010).

Based on the findings presented by various authors, one can notice the possibility that the difference in the level of metacognitive abilities in relation to gender occurs at a certain age due to the different speed at which boys and girls acquire and develop these abilities. This difference starts to decrease after a certain age. The above finding could be verified by carrying out a research in order to examine the level of metacognitive abilities on a large sample that would include different age groups.

4.3. The Relationship between Students' Performance and Metacognition

Pearson correlation is calculated for PKTi and QMi, as well as for PKTf and QMf. Calculation was done for all students unified (Table 4.5), and, separately, for the students in group C (Table 4.6) and the students in group E (Table 4.7).

Table 4.5: *Pearson correlation for QM and PKT for all students*

		PKTi	PKTf
QMi	Pearson Correlation	.311	.203
	Sig. (2-tailed)	.001	.034
	N	110	110
QMf	Pearson Correlation	.317	.252
	Sig. (2-tailed)	.001	.008
	N	110	110

The results for all students showed that students' performance and metacognition were positively correlated for both, initial and final testing. For initial testing calculated values are: Pearson's $r(110) = .311$, $p = .001$; and for final testing: $r(110) = .252$, $p = .008$. Correlation is significant at the 0.01 level (2-tailed).

The R-Squared statistic indicates that students' metacognition explains about 9.7% and 6.4% of the variability in test scores, for pre-test and post-test, respectively. The correlation coefficient equals .311 indicates significant moderate correlation between the variables for initial testing, and value of correlation coefficient .252 indicates significant but weak correlation for final testing.

Additionally, linear regression is carried out. Regression equations for pre-test and post-test are:

$PKTi = -1.869 + .169 \cdot QMi$

$PKTf = 1.660 + .149 \cdot QMf$

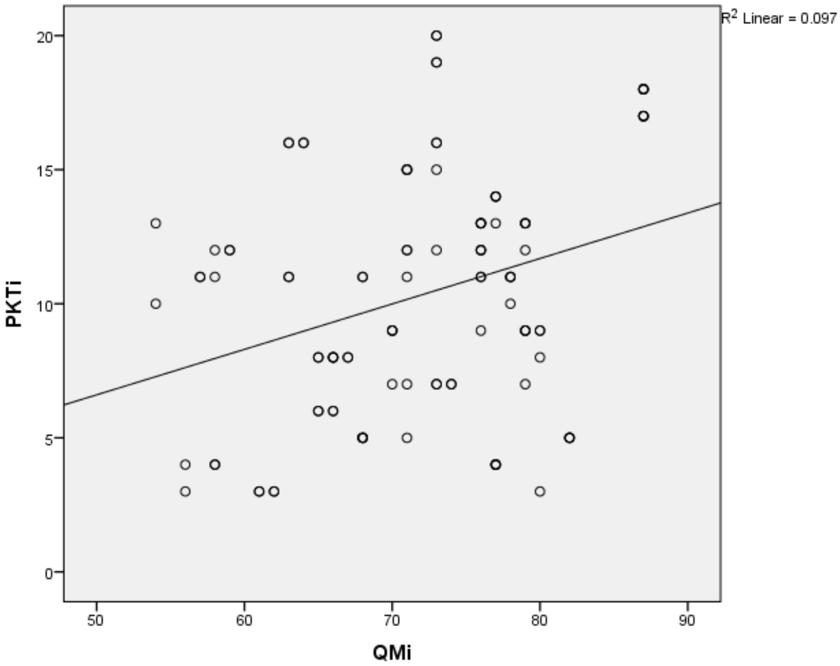

Figure 4.9: *Scatterplot for linear regression: QMi – PKTi for all students*

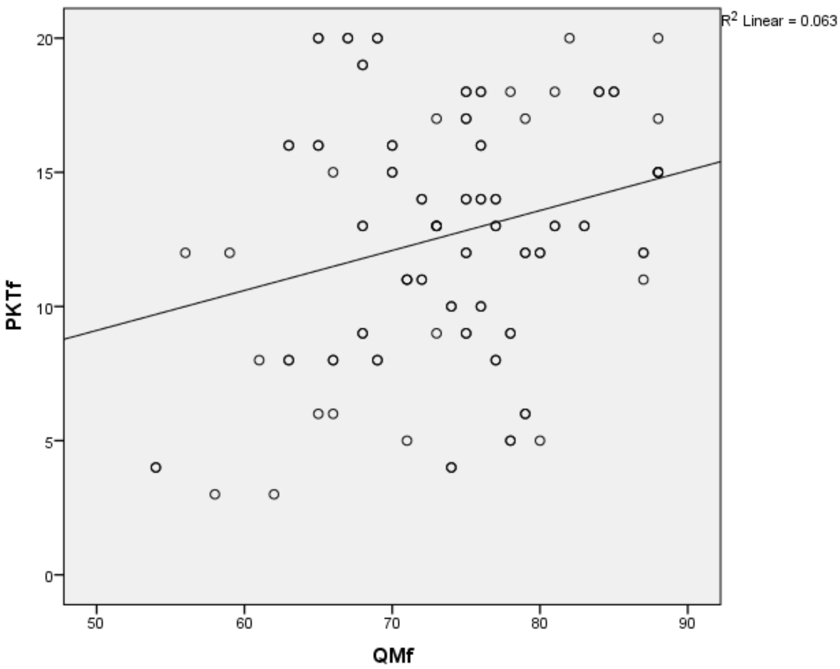

Figure 4.10: *Scatterplot for linear regression: QMf – PKTf for all students*

For the plots above (Figure 4.9 and Figure 4.10), for a given value of QM, the corresponding values of PKT are in a wide range of values. However, linear regression analysis confirmed that these variables are in statistically significant correlation.

Besides, based on Table 4.5, it can be observed that even QMi and PKTf, as well as QMf and PKTi, were positively correlated.

Table 4.6: *Pearson correlation for QM and PKT for the students in group C*

		PKTi	PKTf
QMi	Pearson Correlation	.336	.492
	Sig. (2-tailed)	.001	.000
	N	54	54
QMf	Pearson Correlation	.379	.454
	Sig. (2-tailed)	.005	.001
	N	54	54

For the students in group C, performance and metacognition were positively correlated for initial testing and final testing and also it can be observed that even QMi and PKTf, as well as

QMf and PKTi, were positively correlated. Correlation is significant at the 0.01 level (2-tailed).

Calculated values for initial testing: r (54) = .336, p = .001; and for final testing: r (54) = .454, p = .001, indicate significant moderate correlation between the group C students' performance and metacognition. The R-Squared statistic indicates that students' metacognition explains about 11.3% and 20.6% of the variability in test scores, for pre-test and post-test, respectively.

Regression equations for pre-test and post-test scores of the students in group C are:

$PKTi = -3.045 + .190 \cdot QMi$

$PKTf = -6.642 + .250 \cdot QMf$

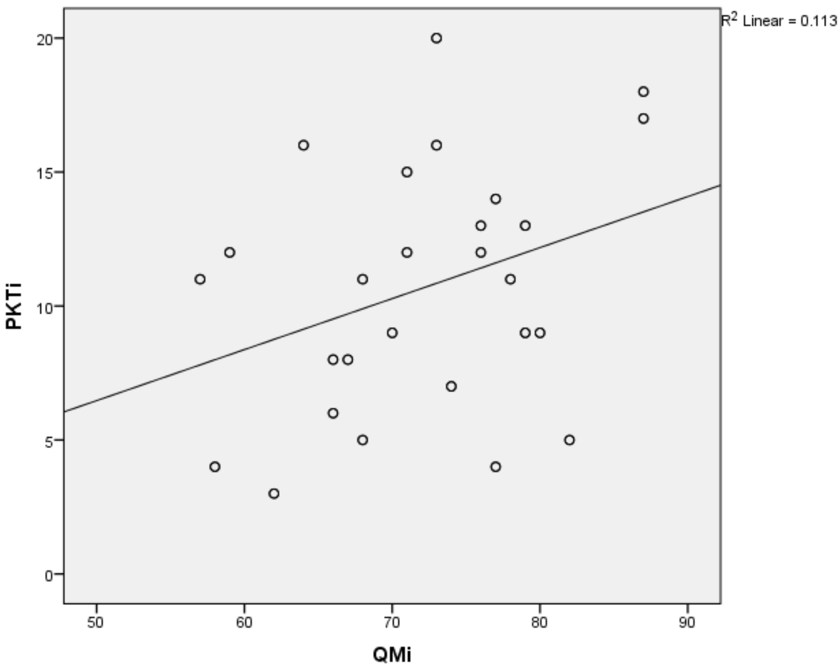

Figure 4.11: *Scatterplot for linear regression: QMi – PKTi for the students in group C*

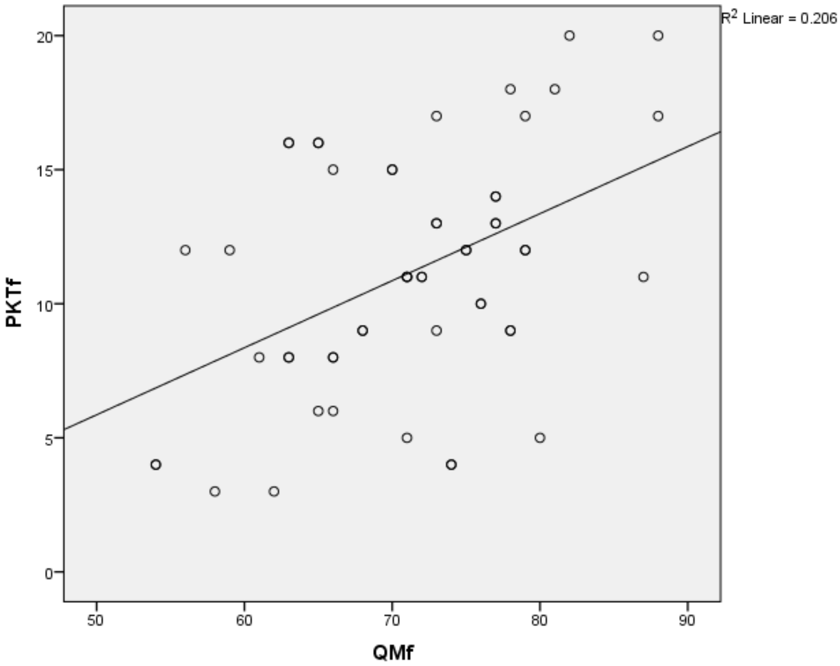

Figure 4.12: *Scatterplot for linear regression: QMf – PKTf for the students in group C*

Although correlations between QM and PKT, for both pre-test and post-test, are proved to be statistically significant for the students in group C, in accordance with indicated strength of correlation, on the scatterplot is shown large data dissemination (Figure 4.11 and Figure 4.12).

Table 4.7: *Pearson correlation for QM and PKT for the students in group E*

		PKTi	PKTf
QMi	Pearson Correlation	.287	-.033
	Sig. (2-tailed)	.008	.808
	N	56	56
QMf	Pearson Correlation	.349	-.205
	Sig. (2-tailed)	.008	.130
	N	56	56

For the students in group E, performance and metacognition were positively correlated for pre-testing and also QMf and PKTi, were positively correlated. Correlation is significant at the 0.01 level (2-tailed).

Calculated values for initial testing: r (56) = . 287, p = .008 indicate significant weak correlation between the E group students' performance and metacognition, before they are taught by using mKWL strategy. Values for final testing: r (56) = -.205, p = .130, indicate that there is no significant correlation between the E group students' performance and metacognition after they are taught by using mKWL strategy. The R-Squared statistic indicates that students' metacognition explains about 8.2% of the variability in test scores for pre-test.

Regression equations for pre-test scores of the students in group E is:

$PKTi = -.790 + .150 \cdot QMi$

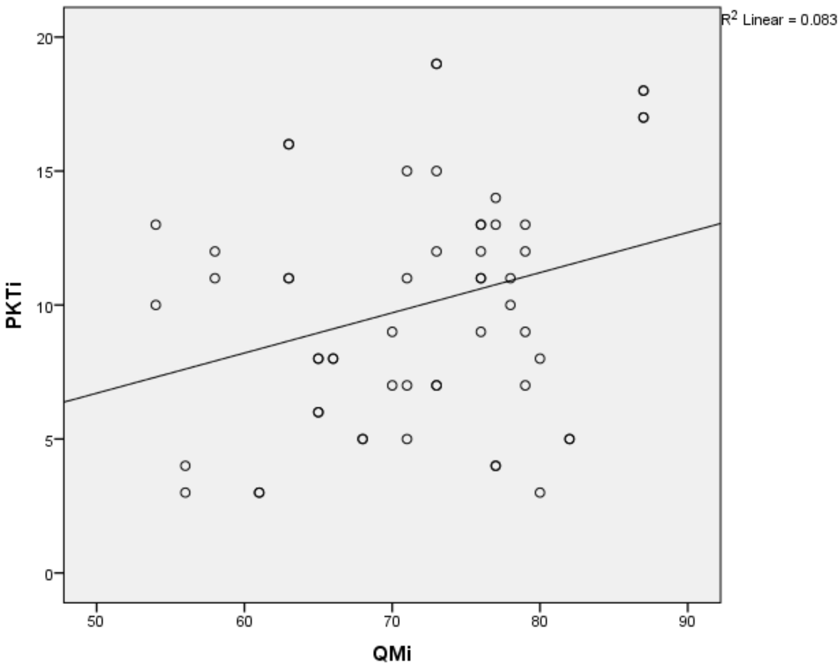

Figure 4.13: *Scatterplot for linear regression: QMi – PKTi for the students in group E*

For the students in group E, statistically significant correlation is shown, but large data dissemination is observed which is in accordance with the strength of the calculated correlation.

This research shows that the relationship between sixth-grade primary school students' performance in physics and metacognition is statistically significant. The calculated correlation between these variables for all students is moderate for pre-test and weak for post-test. This result is due to the fact that used mKWL had different impact on one's physics performance and metacognition. This is confirmed by the result for the students in group E. For final testing for the students in group E there was no statistically significant correlation between students' physics performance and metacognition. At the same time, it is shown that there is statistically significant moderate correlation between the C group students' performance and metacognition on final testing. Based on the above, it can be assumed that, although the used strategy improved both, students' physics performance and metacognition, some students have improved more in physics performance and others in metacognition.

Based on the stated results, hypothesis that there is a significant positive correlation between the students' performance in physics and the development of metacognitive awareness is accepted. Hence it can be suggested that developing of metacognition enables students to be successful learners of physics contents. This finding is consistent with some findings from other authors that have done similar researches but not particularly regarding the physics learning (Kruger and Dunning, 1999; Ozsoy & Ataman, 2009; Singh, 2009; Topcu & Yilmaz-Tuzun, 2009; Rahman et al., 2010; Ku and Ho, 2010; Krebs and Roebers, 2012).

Kruger and Dunning (1999) have shown that improving the students' skills and increasing their metacognitive competence, helped them recognize the limitations of their abilities Ozsoy & Ataman (2009) indicated that the group of students who were instructed to improve their metacognition significantly improved in both, performance in mathematical problem solving and metacognition. Similar findings are given by Singh (2009). Topcu and Yilmaz-Tuzun (2009) showed that students' knowledge of cognition and regulation of cognition contributed to performance in science. Rahman et al. (2010) indicated that students' performance in chemistry and metacognition are correlated (Ku & Ho, 2010) and metacognition can enhance critical thinking (Ku and Ho, 2010; Krebs and Roebers, 2012). According to Remadevi and Kumar (2010) there is a high positive correlation between metacognition and performance (Remadevi and Kumar, 2010; according to Kumari & Jinto, 2014; Devaki and Pushpam, 2011). If students are trained to use metacognitive strategy, they will perform better (Onu et at, 2012); also teaching by the use of metacognitive strategies can improve students' performance (Dejonckheere et al, 2012; according to Kumari & Jinto, 2014). The research carried out in the Republic of Serbia indicated significant moderate correlation between metacognitive skills and student performance in physics for first grade of grammar school (Bogdanović, Obadović, Cvjetićanin, Segedinac & Budić, 2015). Students with metacognitive awarenes developed at a higher level are better strategists and more successful than students with lower level of metacognitive awareness (Garner & Alexander, 1989; Pressley & Ghatala, 1990; Bransford, Brown & Cocking, 2000).

The weak connection between students' performance in physics and metacognition confirms that many factors influence the learning outcome. Sperling et al. (Sperling, Howard, Miller & Murphy, 2002) came to the conclusion that there is a poor correlation between the answer to Jr. MAI and the achievements of respondents in the cognitive domain and therefore expressed their concern about the validity of the research instrument. Lee et al. (Lee, Teo & Bergin, 2009), as a solution to this problem, concluded that children cannot understand and respond well about their metacognitive abilities because they need specific examples in order to understand conception. They are of the opinion that the level of metacognitive awareness as an indicator of metacognitive abilities, therefore, shows slightly less predictive power when it comes to performance.

Students' performance depends on their intelligence. Previous studies showed high positive correlation between students' academic performance and their intelligence (Jensen, 1998). Besides, it is shown that the students' performance in all grades, that is at every age, in schools in Estonia, is highly correlated with their cognitive abilities (Laidra, Pullmann, & Allik, 2007). According to number of authors there is a high positive correlation between cognitive abilities and academic success, however according to the results of various authors, between 51% and 75% of the variance of students' performance is not explained by the cognitive abilities (Rohde & Thompson, 2007). Other variables that influence students' performance are motivation and environment. Students' motivation affects their learning, as well as their confidence when they encounter difficulties in learning (Li & Pan, 2009). However, students' performance can also depend on students' environment. The environment is a complex concept. Environmental factors, among other things, include socio-economic factors, racial, gender and ethnic affiliation, health status. School environment (Glasman & Biniaminov, 1981; Rutter, 1983; Stockard & Mayberry, 1985) and the environment in the family (Burns & Homel, 1985; Kurdek & Sinclair, 1988; Chawla, 2012) impact students' performance.

5. Conclusions

This paper presents the findings of pedagogical experiment performed in order to examine the effect of the mKWL strategy on sixth-grade primary school students' performance in physics and metacognition. Besides, the gender differences in students' performance and metacognition are examined, as well as the relationship between students' performance and metacognition.

A pre-test and post-test control group design was used, where the treatment was the implementation of the mKWL strategy. The research was carried out with 110 sixth-grade students from four different classes of a primary school in Subotica, Republic of Serbia. The same teaching units were taught to the students in both groups for the same time. The topics taught during the research were: (1) Mass and Density and (2) Pressure. The conducted research allowed finding answers to the research questions and to validate proposed research hypotheses.

- According to research results it can be suggested that the use of the mKWL strategy increases students' performance in physics.
- Further, in this research it is shown that students' performance in physics did not depend on gender.
- The research results indicate that the use of the mKWL strategy increases students'metacognition.
- According to research results there was significant difference in students' metacognition related to gender, in favour of girls.
- This study also showed that the relationship between students' physics performance and metacognition is statistically significant, although the correlation is shown to be weak to moderate.

The problem of low students' performance in primary school physics can be overcome, but it will take the time and effort of the researchers in education, as well as the physics teachers.

Besides, while dealing with the problem of low students' performance, students' metacognition can be improved. Negative perceptions of the teaching practice tend to arrive when teachers rely only on direct teaching. The researchers should find the strategies that may be better suited to particular lessons, and the teachers should implement those strategies in practice. The use of appropriate strategy can improve students' comprehension and increase students' performance. The research directed to examine the effect of the mKWL strategy (TQHL charts) on students' performance in physics is carried out. While using the TQHL charts, the students in the experimental group made connections of their prior knowledge and applied it to the new contents. Moreover, students became trained to think as scientists, as well as to implement inquiry process. All this contributed to the acquiring of applicable physics knowledge and enhanced students' performance in physics in the experimental group. Based on the results of research, it can be stated that using the mKWL strategy in the sixth-grade physics class increases students' performance in physics. It helps students to be successful in learning physics contents.

5.1. The Research Limitations

Although the research has reached its aim, the research limitations should be stated. The main limitation of this research is related to the sampling of the groups. The groups were pre-constituted and not selected by random choice. Moreover, the groups were not completely isolated since students were able to communicate outside the school. Consequently, some students in the control group could try to apply the mKWL strategy introduced to the students in the experimental group. In addition, this research included only sixth-grade students and just two physics topics.

Besides, the collecting data about students' metacognition is based on questionnaire that records self-reported data. Those data cannot be independently verified and attribution can become apparent. Students can try to attribute positive outcomes to their own competences. Another concern is the fact that children cannot understand their own metacognitive abilities (Lee, Teo & Bergin, 2009).

An important limitation of the researcher should be noted, that is is fluency in a language. Since the researcher is not fluent in Serbian language and was limited in being able to read and interpret the original teaching material which is used, it was necessary to translate the material. Therefore, the researcher may have missed some additional insights.

5.2. The Implications for the Practice and the Further Research

The implications for the practice and the further research derive from the results of this research. It can be suggested to implement the described strategy in teaching physics in order to improve students' performance and metacognition. Additionally, teachers can use the TQHL charts in order to notice possible students' misconceptions about teaching contents and to assess students' prior knowledge. The teachers can be successful in using the proposed strategy in class if they receive needed material and training about the TQHL charts. Therefore, it is necessary to carry out the additional teachers' professional development and teachers should be trained to implement this strategy. This can be achieved by planning analysis of this teaching strategy within teachers' education curriculum. Besides, appropriate materials and other resources should be provided. The teachers should teach students not only about the given topics but about using useful learning strategy as well. As soon as students adopt using the TQHL charts during their physics class, they will use the KWL strategy or its adequate modifications for learning other subjects as well. The problem of applying this strategy in primary schools in the Republic of Serbia is reflected in limited time available for the realization of each teaching unit. This problem can be overcome by teachers' good planning and organizing skills. Although the application of the TQHL charts requires from teachers more time in order to prepare their lessons, the use of the TQHL charts helps students to successfully acquire teaching contents.

When using TQHL charts, students should state their assumptions and propose hypotheses without fear of being wrong. Consequently, it is important to keep in mind that when using this strategy as a whole class activity, or as a group activity, it is possible that students memorize false assumptions of other students. Because of that, it is especially desirable for students to conduct a research that will form the scientific knowledge in place of the existing misconceptions. In accordance with the above, an important task of teachers is to teach students to check their assumptions by various experiments, instead of constantly searching the Internet.

This research raises new questions and gives some new directions for the further research, that should include wider teaching contents and different grade levels for obtaining additional results regarding this issue. Since the use of the TQHL charts is not sufficiently studied, more findings of using this strategy will be gained by extending this research. Further research can investigate the effects of described strategy on attitudes toward science, students' motivation, cognitive load or other variables. Using the mKWL strategy in teaching physics can have more positive effects than indicated in this research.

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7. Appendixes

7.1. Pre-test (PKTi)

Physics Knowledge Test for 6th Grade Students

Circle the letter in front of the answer that you think is correct. Each question has only one correct answer.

1. **To describe force, it is sufficient to indicate:**

   a) direction

   b) magnitude

   (c) magnitude and direction

2. **What is physical quantity?**

   (a) a property of a body, substance or phenomenon that can be measured or counted

   b) a unit of measurement

   c) a number

3. **The International System of Units (SI) defines __?__ base units.**

   a) 3

   b) 5

   (c) 7

4. **Which of the following physical quantities represents the base one?**

   (a) mass

   b) surface

v) pressure

5. **What is the measurement unit of speed?**

 a) m/s^2

 (b) m/s

 c) N

6. **Gravity was described by:**

 a) Pascal

 (b) Newton

 c) Ohm

7. **A rock is placed on a surface of the Earth. Name a force that excerts on the surface.**

 (a) weight

 b) Earth's gravity

 c) mass

8. **Which of the two bodies is undoubtedly slower?**

 a) the one exceeding larger distance for a longer time interval

 b) the one exceeding the same distance for a shorter time interval

 (c) the one exceeding the same distance for a longer time interval

9. **By hanging an additional weight on an elongated elastic spring of a dynamometer, the spring will:**

 (a) stretch further

 b) compress

c) there will be no change

10. **In order to calculate the volume of a rectangular cuboid it is sufficient to measure:**

a) the height

b) the longest edge

(c) all the edges (length, width and height)

11. **If the measured values for length are 355 mm, 356 mm and 357 mm, what is the average value of the measured length and what is the largest absolute error of these measurements?**

a) 355 mm; 1 mm

(b) 356 mm; 1 mm

c) 1 mm; 356 mm

12. **A graduated cylinder is filled with water and an object is placed inside; they occupy the volume of 33.8 cm^3. If the object has the volume of 8.2 cm^3, how much water fills the graduated cylinder?**

a) 33,8 ml

b) 42 cm^3

(c) 25,6 ml

7.2. Post-test (PKTf)

Physics Knowledge Test for 6th Grade Students

Circle the letter in front of the answer that you think is correct. Each question has only one correct answer.

1. **Mass is the measure of:**

   a) volume

   (b) inertia

   c) density

2. **Homogenous bodies:**

   a) have different densities in some of their parts

   (b) have the same density in all their parts

   c) are in the form of a cube

3. **Newton's first law of motion states that:**

   (a) Every object persists in its state of rest or uniform motion - in a straight line unless it is compelled to change that state by forces impressed on it.

   b) A body moves only when a force acts on it.

   c) Force is the cause of the movement of a body.

4. **The SI unit for pressure is:**

   a) Kilogram (kg)

   b) Newton (N)

   (c) Pascal (Pa)

5. **Pascal's principle states that:**

   (a) External pressure is transmitted through liquids or gases equally in all directions.

   b) External pressure is not transmitted in all directions through liquids or gases

   c) External pressure is never transmitted through liquids or gases

6. **Normal atmospheric pressure at the sea level is:**

   a) 101,3 Pa

   b) 1,013 kPa

   (c) 101,3 kPa

7. **In order to calculate an object's density, one needs to know:**

   a) its weight

   b) its mass

   (c) its mass and volume

8. **The unit for pressure Pa is equal to:**

   a) kg/m^3

   (b) N/m^2

   c) N/m^3

9. **If the same liquid is poured to same level in two vessels having different volumes, the pressure at the bottom of the vessel:**

   a) will be higher in the vessel of greater volume

   (b) will be the same in both vessels

   v) will be larger in the vessel of smaller volume

10. **If two bodies have equal masses, and the contact surface of the first body and the floor is greater than the contact surface of the second body and the floor:**

a) The pressure exerted by the first body is greater than the pressure exerted by the second body

(b) The pressure exerted by the second body is greater than the pressure exerted by the first body

c) We cannot know which body exerts greater pressure

11. **The maximum load of a lift is 3000 N. A girl, a boy and two men are waiting for the lift. Their masses are 40 kg, 50 kg, 70 kg and 90 kg, respectively. Will they be able to fit into the lift?**

(a) yes

b) no

c) we can not know based on the given data

12. **A table on four legs has weight of 40 N. Each leg sets against the floor with the area of 0.001 m2. What pressure does the table exert on the floor?**

a) 400 Pa

b) 1000 Pa

(c) 10 000 Pa

d) 40 000 Pa

7.3. Test Items Classified Using Bloom's Taxonomy of Educational Objectives

For both, pre-test and post-test:

Cognitive level	Test items
Remembering	1, 2, 3, 4, 5, 6
Understanding	7, 8, 9, 10
Applying	11, 12

7.4. Metacognitive Components Evaluated Using Jr. MAI

Metacognitive components		Test items
Knowledge of cognition	Declarative knowledge	1, 4, 12
	Procedural knowledge	3, 16
	Conditional knowledge	2, 5, 13, 14
Regulation of cognition	Planning	8, 9, 17
	Information management	6, 11
	Monitoring	10, 15
	Evaluating	7, 18

Biography

Zekri Zouhor was born on 1 August 1986 in Surman, Libya. She finished primary school in Surman, in 2000, as an excellent student (100/100). In the same town, in 2003, she finished high school, as an excellent student (88/100) as well. She acquired a bachelor's degree in physics (achieved success of 84/100) at the Faculty of Sciences in Abu ‘Isa, Az Zawiyah, University of Zawiyah, in Libya, in 2007. Upon completing her studies, based on the achieved success, she was entitled to a state scholarship. As a scholar of the Ministry of Education of the State of Libya, in the academic year 2010/2011 she was enrolled in master academic studies in the Republic of Serbia at the Department of Physics at the Faculty of Science and Mathematics, University of Novi Sad. She successfully completed master studies in 2012 and gained the academic title of master in physics (module: teaching). She was awarded with a scholarship of the State of Libya to further continue her education and in the academic year 2012/2013 she enrolled doctoral academic studies of teaching methods of natural sciences (physics) at the Faculty of Natural Sciences and Mathematics in Novi Sad, Department of Physics. She successfully passed all the exams according to the selected study programme. She decided to do research in the field of physics education, with particular interest for the application of different strategies in teaching physics in order to achieve higher students’ achievement. She is the coauthor of two papers published in scientific journals and one presented at the international conference. Since the academic year 2008/2009 she has been employed as a teaching assistant at the Department of Physics of the Faculty of Sciences in Abu ‘Isa, Az Zawiyah, University of Zawiyah, in Libya.

Novi Sad, March 2018 Zekri Zouhor

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	control) was carried out; 141 students (5 classes) of the sixth grade (aged 11-12 years) participated. Students' performance was assessed with the use of pre-test and post-test that were created for the purpose of research, while questionnaire on metacognition was used for evaluation of students' metacognition. Statistical analysis of the obtained data showed that the implementation of the modified Know-Want-Learn strategy, in sixth grade primary school physics teaching, has positive impact on students' performance and metacognition. Besides, it has been shown that performance is not dependant, while metacognition is dependant on students' gender. On the basis of the obtained data, it was found that there is statistically significant weak correlation between students' performance and metacognition. The research results suggest that proposed strategy should be used in primary school physics teaching.
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Važna napomena: VN	Nema
Izvod: IZ	Učenici doživljavaju fiziku kao težak nastavni predmet i imaju predrasude o fizici kao nauci i pre nego što se upoznaju sa njenim sadržajem u okviru nastave fizike. Slaba postignuća učenika iz fizike ukazuju na potrebu da se u nastavi primenjuju odgovarajuće strategije koje mogu pomoći učenicima u savladavanju sadržaja fizike. S obzirom na to da postoji veza između postignuća i metakognicije učenika, poželjno je primenjivati strategije koje istovremeno podstiču razvoj metakognicije. U ovom radu je predložena modifikovana strategije Znam-Želim da znam-Naučio sam, koja se može koristiti u nastavi fizike s ciljem podsticanja istraživanja i praktičnog rada. U okviru modifikovane strategije učenici popunjavaju tabelu od četiri kolone: Mislim i znam; Pitanja koja imam; Kako mogu da saznam; i Naučio sam. Cilj sprovedenog istraživanja bio je da se ispita uticaj primene modifikovane strategije Znam-Želim da znam-Naučio sam postignuća i metakogniciju učenika u osnovnoškolskoj nastavi

	fizike. U realizovanom pedagoškom eksperimentu sa paralelnim grupama (eksperimentalnom i kontrolnom), učestvovao je 141 učenik (5 odeljenja) šestog razreda (uzrasta 11-12 godina). Postignuća učenika su procenjena primenom inicijalnog i finalnog testa koji su kreirani za potrebe istraživanja, dok je za procenu metakognicije učenika korišćen upitnik o nivou metakognicije. Statističkom obradom dobijenih podataka pokazano je da primena modifikovane strategije Znam-Želim da znam-Naučio sam, u realizaciji nastave fizike u šestom razredu osnovne škole, pozitivno utiče na učenička postignuća i metakogniciju. Takođe, pokazano je da postignuća ne zavise, dok metakognicija zavisi od pola učenika. Na osnovu dobijenih podataka utvrđeno je da postoji statistički značajna slaba korelacija između učeničkih postignuća i metakognicije. Rezultati istraživanja ukazuju na to da bi opisana strategija trebalo da se koristi u osnovnoškolskoj nastavi fizike.
Datum prihvatanja teme od strane NN veća: DP	
Datum odbrane: DO	
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